AN ARISTOTELIAN DIALOGUE CONCERNING THE GEOCENTRIC AND HELIOCENTRIC COSMOLOGIES, CONTRA GALILEO

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INTRODUCTION

This dialogue is a defense of Aristotle and the Peripatetic school against the refutation of their cosmological arguments by Galileo in his *Dialogue Concerning the Two Chief World Systems*. It is only fitting that a dialogue refute a dialogue. The dialogue form used by Galileo was impactful because it contended against the scholastic or peripatetic doctrines of the previous age, whereas Copernicus and the other main figures of the scientific revolution did not argue against the contrary cosmological hypothesis as much as compile tables of observations of data in support of their own. Galileo is the central figure in that movement because he attacked the scholastic and peripatetic position about cosmology, rather than merely compiling data and figures in tables in reference to and support of the heliocentric cosmology originally put forth by Copernicus. This work, then, argues for the geocentric cosmology against that of the heliocentric by attacking the heliocentric as much as by propounding arguments in favor of the geocentric and peripatetic cosmology. And the form in which this work is written is that of a dialogue, for the reason that contention between opposing viewpoints is directly resolved thereby. The opposing view, therefore, has to be addressed for resolution to be possible, in any case, and dialectic is the primary means of debate between opposing viewpoints.

Aristotle's works that address cosmology are, primarily, his *On the Heavens* and the *Physics*, which I should say something about, since many of the arguments made in this dialogue are extracted from those works. First, I should note that the writings of Aristotle which have been preserved to this day are his lecture notes, not works meant for publication and distribution. He wrote dialogues which have since been lost to antiquity. His 'lecture notes', which are wrongly considered as his formal writings, are 'dialectical', nonetheless, even though there are not multiple characters arguing over contentious points. The dialectic takes place within his own mind, as a stream of though mulling over the consequences of proposed hypotheses, without a second disputant. Thus, in the writings of Aristotle a variety of opposing viewpoints are set forth and then subsequentially disproved, and his personal viewpoints are never set forth as doctrine, although many of his opponents, and arguably his successors, have made them out to be, or, at least, the appearance has become such among those who lecture about him.

His expertise in philosophy, aside from logic, about which he is undoubtably the authority, for compiling the complete arrangement of valid forms of proof, lays concentrated in the fields of physics and astronomy, about which Plato, his instructor for twenty years, considered as indeterminate and indefinite, and so withheld any claims about those topics. Aristotle directly addressed the heliocentric theory, and provided fortified arguments against that position, from which it is possible to apply those arguments against the heliocentric theory that arose during the scientific revolution and has hitherto remained in vogue. Upon reading his *Physics* and *On the Heavens*, however, one gets the impression that he is not employed in materialistic speculation, for, those works verge more so on theology and metaphysics than physics as it has been theorized about since the scientific revolution. Thus, Martin Heidegger said that—

"The *Physics* is a lecture in which he seeks to determine beings that arise on their own, τὰ φύσει ὄντα, with regard to their being. Aristotelian "physics" is different from what we mean today by this word, not only to the extent that it belongs to antiquity whereas the modern physical sciences belong to modernity, rather above all it is different by virtue of the fact that Aristotle's "physics" is philosophy, whereas modern physics is a positive science that presupposes a philosophy.... This book determines the warp and woof of the whole of Western thinking, even at that place where it, as modern thinking, appears to think at odds with ancient thinking. But opposition is invariably comprised of a decisive, and often even perilous, dependence. Without Aristotle's Physics there would have been no Galileo."[1]

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[1] *Matin Heidegger. The Principle of Reason.*

Since the *Physics* and *On the Heavens* might seem rather sporadic in that a variety of different positions are refuted, such as that of a flat earth, I have arranged the arguments relevant to and against the heliocentric model of the cosmos into a dialogue between interlocutors. Galileo, himself, is one of the disputants, the other being Simplicius of Cilicia. I chose Simplicius as the mouthpiece of Aristotle's arguments because he is the model upon which the character that defends the Peripatetic positions in Galileo's own *Dialogue Concerning the Two Chief World Systems* is styled. Galileo, then, uses 'Simplicio' as his opposition and contends with the Peripatetic cosmology through dispute with this character. There is an unfortunate confusion about Galileo's character Simplicio. He is thought by those unfamiliar with the commentators of Aristotle to have his name derivative of the insult 'simpleton'. However, there is no doubt that Galileo was referencing Simplicius of Cilicia, the fifth or sixth century commentator on those particular works of Aristotle. There is, perhaps, no more important commentator on the works of Aristotle that we have access to.

Since, in my opinion, Galileo misrepresents the arguments of Aristotle through his character styled after Simplicius of Cilicia, I use Simplicius as a character in this dialogue as the main proponent of the Peripatetic cosmology, who I portray as discoursing with Galileo himself, instead of with the other characters used by Galileo, Salviati and Sagredo. There is a problem relating to the timeframe of the dialogue since the characters Simplicius and Galileo are separated by eleven hundred years. I, however, hold Galileo responsible for that discontinuity, and attribute any confusion in timeframe and setting to him, since he indeterminately used a character modeled after Simplicius of Cilicia without giving any explanation and without clarifying if some Peripatetic philosopher was called by that name in his own time. To avoid confusion, I disregard the discontinuity in the timeline and place the sixth century philosopher Simplicius of Cilicia in the same setting as Galileo. That is the only way I could conceive of preserving the character Simplicius as partaking in a conversation with Galileo, and, in honor of the great commentator, solidifying the reference and imitation of him in Galileo's character 'Simplicio', while granting the sixth century commentator and champion of the Peripatetic school an opportunity to defend the positions of Aristotle against the Copernican theories of the scientific revolution. Thus, I would have rather avoided disturbing the historical timeline by throwing characters against each other in dispute from different eras, however, there is an invaluable significance in Galileo's choice to represent Simplicius of Cilicia in his character Simplicio, and, since he sets them in the same scene without explanation, I feel no guilt about clarifying the identity of the disputants and disturbing the timeline. In order to make up for this awkward arrangement of characters a thousand years apart taking part in a discussion in Galileo's time, I set the conversation within a dream of Scipio Aemilianus. This is in accordance with Cicero's *De Res Publica*, where the final book has the same context, and is called "The Dream of Scipio." Part of my reason for making up for the disruption of the timeline between coinciding characters by placing the conversation within a dream of Scipio Aemilianus, is that Cicero's work with the same kind of setting about the same person portrays the geocentric cosmological system that was attacked by Galileo, and which I depict Simplicius of Cilicia as defending. Thus, there is significance within the argument to the debate taking place within 'a dream of Scipio Aemilianus', since in Cicero's *De Res Publica*, Scipio is shown the layout and arrangement of the spheres that encircle the earth, the arrangement of which was the target of refutation taken by Galileo in the seventeenth century. That is all, however, not a result of my imaginative license, but an attempt to smooth over the discontinuity in time between characters.

Within the setting of 'a dream of Scipio Aemilianus', however, which is only required to explain the presence of Simplicius of Cilicia, the conversation is set within a largely historically accurate framework. Since my intention is to defend the Aristotelian geocentric model against the previous attacks made thereupon by Galileo, I set the conversation within the 'trial and judgement of Galileo' during the Roman Inquisition, and have the court summon the Copernicans led by Galileo to a discussion of contest between the two cosmological systems, for the sake of clarification about the Copernican position and also to make a formal evaluation and decision about how to deal with the proponents of that view. Galileo, of course, really had confrontations and trials during the Inquisition regarding these points, so no part of that setting, besides the presence of Simplicius of Cilicia, is fantastical or imaginative. I should also say that although the conversation is set within a dream of Scipio Aemilianus, he is a mere bystander that does not participate in the discussion that, as I have said, takes place during the Roman Inquisition during the later years of Galileo. That also is advantageous for the Peripatetic side of the dispute—placing Galileo in a position where he may be interrogated by Simplicius of Cilicia under the order of the Roman authorities who have summoned him there for a hearing, or really, a contest of dispute between the geocentric and heliocentric cosmologies. There is, then, a manner in which Galileo is under compulsion to comply to the interrogation made by Simplicius of Cilicia.

I have Simplicius display many arguments that are directly taken from Aristotle's *On the Heavens* and *Physics*. I, nonetheless, arrange them so as to make them apply dialectically with a disputant, and often retrieve them from various places in his writings and then set them forth in cohesion towards the purpose of the discussion with artistic skill. Galileo's responses, and his questions also, are largely derived directly from his *Dialogue Concerning the Two Chief World Systems*. An excessive amount of footnotes are provided to make evident that what I portray Galileo as saying, was what he had the characters in his dialogue, especially those that argue for his own viewpoint, say. Many other arguments are entirely my own and aren't adopted from Aristotle's writings, especially in Book II, which is where the main cosmological contention occurs.

This dialogue is made in defense of Aristotle and the geocentric cosmology from and against the Copernican heliocentric theory of Galileo, designed specifically as a response to Galileo's *Dialogue Concerning the Two Chief World Systems* and his arguments against the Peripatetic view of the arrangement of the cosmos therein. As I interpret Galileo as misrepresenting the arguments of Aristotle as portrayed through the character 'Simplicio' in his dialogue, I portray that same character, who was styled after the sixth century commentator Simplicius of Cilicia, as contending with the challenges set against him in Galileo's dialogue, with Aristotelian arguments that are neither misrepresented, nor filtered through the bias of an opponent, nor weakened by an inadequate grasp of Peripatetic positions and forms of reasoning. I, thus, address the problems and challenges set forth by Galileo against the Aristotelian theses directly, and set forth, in turn, arguments against the heliocentric model of the cosmos from Aristotle's "On the Heavens" and "Physics", which were insufficiently displayed in Galileo's *Dialogue Concerning the Two Chief World Systems*. The topics and questions covered in this dialogue and those in Galileo's are the same, and the characters are for the most part the same, aside from the fact that I replace the characters that Galileo has argue his own views against Simplicius with Galileo himself, and I have the setting of the discourse take place as part of Galileo's trial in the Inquisition, where he is summoned for a contest and exposition between the two cosmologies.

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SETTING:

A DREAM OF SCIPIO AEMILIANUS ABOUT FUTURE EVENTS REGARDING THE MISFORTUNES OF ROME

Scipio Aemilianus: Two years after the conquest of Carthage, I embarked on an embassy to Asia and Egypt, specifically to the states in those regions that are in alliance with Rome. I was accompanied by Polybius the historian and Panaetius of Rhodes, the Stoic philosopher. While we were stationed in Pamphylia, on the southern coast of Asia Minor, and after an evening full of discourse, upon which I was fortunate enough to witness a many sided discussion between Panaetius of Rhodes and Polybius, sleep enfolded me in a closer embrace than was usual. Hereupon there appeared to me, for my part I believe, out of what we had been talking about: for it often happens that our thoughts and conversations give birth in sleep to some such fancy as that which Ennius records about Homer, of whom, to be sure, in his waking moments he was wont to think and talk very often—[2] a dream filled with the contentious debate of characters peculiar to me, yet contending over subjects which I had previously heard discussed by Panaetius and Polybius. The place was familiar— our own glorious city—but the time was altogether unfamiliar and strangely distant, and I felt like a foreign visitor, not partaking myself in the conversation which I observed, but listening as a bystander, much like I had in the company of Polybius and Panaetius of Rhodes. I herein record and relate what I was witness to in the dream.

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[2] *Cicero. Somnium Scipionis.* II.

BOOK I.

Pontifex Urban VIII: You, Galileo, and you other followers of Copernicus, like Salviati and Sagredo were, and you onlookers and listeners —you have been summoned here by the authorities of Rome for a contest against and a formal evaluation of the new doctrines of Galileo and Copernicus. About which, Galileo will be compelled to defend the Copernican cosmology, as he is their greatest proponent against the Aristotelian theses. He will be defending the Copernican theories from the challenges and refutations posed to him by Simplicius of Cilicia, the great commentator on the writings of Aristotle. I, then, hand over the role of conducting the discussion to you, Simplicius, to interrogate Galileo as you wish and as you see fit.

Simplicius of Cilicia: To begin— Galileo, do you and the Copernicans not propose theories that displace the stationary Earth from its place at the centre of the cosmos, in exchange for a stationary Sun at the centre, and don't you further argue for irregular cycles and imperfections of the heavenly bodies, in denial of the separate and different substance and nature of the aethereal heavens from that of the sublunary elemental

bodies, with your culmination taking place in the claim that the heavenly spheres and the bodies carried around in them are not eternal, ingenerated, and incorruptible?
Galileo: Yes, and shamelessly, with exception of the last point about our denying the eternality of the heavens, for that claim hasn't been laid against us by our opposition as of yet.
Simplicius of Cilicia: Then tell me this. In your vain presumptions of making the Earth seem to be no different in substance and motion from the luminaries, is it your intention to drag down the heavens into the sublunary and changing realm, and to throw the Earth's position and station into confusion, or do you really consider yourselves to be saying something that raises the Earth up from the interpretation of its place in the cosmos handed down to us from the ancients?
Galileo: We consider ourselves to be following the trail of truth, without concern to the authoritative doctrines of the ancients.

Simplicius of Cilicia: Then since this isn't a trial, but a discussion summoned by the authorities of Rome, since you have already been sentenced to house arrest and stand the future charges of influencing a variety of like-minded writers, you may contest with me about the two chief world systems, the Aristotelian and the Copernican cosmologies. And know that such is not as much an invitation but, as you know, an order from the court of Rome, to present your arguments for the Copernican system and state your qualms with the Aristotelian cosmology. I waste no effort in asking you what few points you disagree with the Aristotelian world view, since as I understand, you take up arms

against every single postulate, premise, conclusion, and even anecdote. So, we will have to survey both of the chief world systems, the Aristotelian and the Copernican, in a discussion that will either end in the remedy of your mental and intellectual distortion or in another trial with greater implications, given your influence on your contemporaries since the time of your mild sentence under the authorities of Rome.
Galileo: I submit to your inquiries.

Simplicius of Cilicia: Then, I hope also that you submit to the rules of argumentation. Now, it is clear that the two different views of the world differ in two manners, first, that the Aristotelian side claims the ingenerability, indestructability, incorruptibility, and inalterability of the cosmos, while the Copernicans claim the alterability, destructibility, and generability of the same cosmos, and second, that the Aristotelians place the Earth as unmoved at the center of the Cosmos, while the Copernicans displace the Earth from the center of the Cosmos and grant it a variety of motions. Now, since it would be difficult and unorderly to begin with your—the Copernican—estranged conclusions, since you avoid demonstrative argumentation, and attack, or rather merely deny, Aristotle from irregular angles, we are forced to begin at the beginning in order to find common footing for our arguments. And since, in your work titled *Dialogue Concerning the Two Chief World Systems*, you began with Aristotle's premises and gradually strayed from and contended with them[3], until alas you

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[3] *Galileo. Dialogue Concerning the Two Chief World Systems.* Pg. 9-18

left not even a single postulate, let alone proposition, untouched by your slander, we will begin where you did, at the onset of Aristotle's arguments taken from his lecture notes titled *On the Heavens*. I will seek your agreement throughout the whole from there, and we will contend with each other or agree, since, as I and many others suppose, you misrepresented the philosopher's arguments, and I will play the part of 'Simplicius' through who as a literary mouthpiece you profaned the arguments of the great philosopher Aristotle. Otherwise, if we begin with your rash conclusions, I'm afraid there will be no common footing to take up arms in the course of the argument, since it is clear that you don't use premises and synthesize conclusions in your observational claims.
Galileo: Then let us begin at the beginning with Aristotle's first premises in his work *On the Heavens*, as I did in my own work.

Simplicius of Cilicia: Are you and your friends, Saviati and Sagredo, that is Filippo Salviati and Giovanni Francesco Sagredo, familiar by way of instruction with Aristotelian physics?
Galileo: We claim to have understood scholastic physics to a higher degree that their own adherents.
Simplicius of Cilicia: Then, as they have both since passed away, and before that Filippo Saviati fled Florence from the Medici family, after also being warned about a complaint received by the Holy Office regarding his heresy, and Sagredo was accused of espionage around the same time, you will have to speak for them, for you used them as your mouthpiece in you're *Dialogue Concerning the Two Chief World Systems*. And know that you are defending yourself

and the Copernican system by speaking for them, as those are what are left at stake.
Galileo: It is second nature for me to speak for them and for the Copernican world view, as you know, since I used them as my mouthpiece to speak for me and the Copernican cosmological system.
Simplicius of Cilicia: Then let us proceed with the argument.
Galileo: At your lead.

Simplicius of Cilicia: You must agree that the science which has to do with nature concerns itself with bodies and magnitudes and their properties and movements, do you not?
Galileo: Of course.
Simplicius of Cilicia: And what say you about the principles of bodies and magnitudes, does an understanding of them on their own right provide us with a greater understanding of bodies and magnitudes and their movements that comprise nature and the processes of nature?[4]
Galileo: I assent, yet I wish you would explain the difference and what principles you suggest.
Simplicius of Cilicia: And I yield to your wish, as much for my own pleasure as for the sake of the argument. You distinguish between shapes and the science of shapes, that is, geometry, and bodies which by necessity have shape and the science of the movements of those bodies, that is, physics, do you not?
Galileo: I do.

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[4] *Aristotle. De Caelo*. I. 268a, 1

Simplicius of Cilicia: And don't you say, along with us, that the science of shapes in and of themselves, I mean geometry, has certain principles from which we gather an arsenal of propositions useful in demonstrating conclusions?

Galileo: Yes.

Simplicius of Cilicia: These axioms or postulates, as we call them, are taken to be self-evident and impossible to doubt, granting us a sturdy foundation from which to construct demonstrations of other propositions. Axioms or postulates, then, are what I mean by principles of a science. The following are such axiomatic and self-evident truths: A point cannot be divided; a line is a length without breadth; the limits of lines are points, or in other words, lines are bounded by points; the limits of surfaces are lines, or, likewise, in other words, surfaces are bounded by lines. Is that clear to you?

Galileo: It is.

Simplicius of Cilicia: Do you also consent to the statement that the science of geometry as a whole is set over the science of motion, or physics, as a whole, as a sort of principle? What I mean is this. Physics, or the science of moving bodies, in so far as it has as its subject bodies or magnitudes, and since bodies are comprised of shape or figure, and in so far as motion takes place along linear spaces, along the outline of some shape, that science is dependent upon and bound together with geometry, the science of shapes. What response have ye to the claim that no proposition in physics could be stated without adopting or employing geometrical terms?

Galileo: I consent also to that, although I reserve the doubt that bodies in the world fail to achieve the definitional form of purely geometrical shapes.
Simplicius of Cilicia: Such a doubt I also hold, and such need not be dwelled upon yet. Nonetheless, you must admit that we are required to use geometrical terms such as straight, circular, spherical, surface or plane, flat, round, continuous, point, line, and so on, in our discourses about physics.
Galileo: Yes, even if we use the geometrical terms in a less precise sense when applying them to physical problems.
Simplicius of Cilicia: I should interject the course of the argument to remind you that the relationship between geometry and physics is one way, and not reciprocal, for geometry never takes anything from physical inspections.
Galileo: Yes, I know.
Simplicius of Cilicia: Then, since we are in agreement about the claim that physics has to do, not only with bodies and magnitudes and their movements, but also with the principles of bodies and magnitudes, we might move on to the general course of the argument.
Galileo: You may go on with the argument.
Simplicius of Cilicia: You admit that the magnitude that we call a continuous line is always capable of subdivision, do you not?[5]
Galileo: Yes
Simplicius of Cilicia: And that a line is divisible in one way or by one interval only?[6]

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[5] *Aristotle. De Caelo.* I. 268a, 5

[6] *Aristotle. De Caelo.* I. 268a, 7-8

Galileo: Yes
Simplicius of Cilicia: And that a magnitude which is divisible in two ways or two intervals is a surface?
Galileo: Yes
Simplicius of Cilicia: Then do you also agree that a magnitude which is divisible in three ways is a body, having volume, as we say?
Galileo: Yes that also.
Simplicius of Cilicia: And these we call dimensions, divisibility along one, two, or three ways or intervals?[7]
Galileo: Yes
Simplicius: Are not surfaces distinguished from lines, and bodies from surfaces, by the addition of a perpendicular line? I will provide the reason for making, after illustrating, such a qualification. Not by the addition of any random line is the result of a further dimension passed to from a given figure. Take a surface, for example. A line that projects the area in line with and along the plane of the given surface doesn't grant the figure a third dimension. For the given surface was only capable of division in two ways, length and width, and an additional extension in length or width wouldn't and doesn't add the interval or dimension of depth to the given surface. Only by extending and protruding the surface in the direction along an interval that runs against and across its superficial intervals of length and breadth is the interval of depth added to the prior surface; that is by the addition of a line perpendicular to the lines that determine and measure the other two intervals of dimension. And of course the interval of width is

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[7] *Aristotle. De Caelo.* I. 268, 8-10

added to a length by the addition of none other than a perpendicular line through the center of the given line, or, at least, even if we admit that width or breadth is added to a given line or a length by the addition of a second line that is not at right angles to the given line, we refuse to measure the second dimension of breadth by any line that is not at right angles to the given length. And likewise in the measure of a volume or body, if the dimensional lines are not set at right angles there is no value in our calculation of the volume, for lack of (angular) definitude. As then, the mensuration of the intervals of dimension depends on perpendicular lines set at right angles with each other, we say that the dimensions of length, breadth, and depth are set perpendicularly from each other. Do you follow the argument?

Galileo: Yes, I follow.

Simplicius of Cilicia: Then answer this.

Galileo: What?

Simplicius of Cilicia: Upon the intersection of three perpendicular lines of interval, is it possible to draw a fourth that is perpendicular to them? You must realize that from a line of a single dimension, an additional perpendicular line (of breadth) that intersects the prior line (of length) divides the angular space equally, and that a further additional perpendicular line (of depth) that intersects the two previous intervals (of length and breadth) also divides the whole angular space equally. So I ask, is it possible to draw a fourth line perpendicular to the three intersecting lines that carve out the intervals of length, breadth, and depth, that divides those prior intervals equally, without allotting disproportionate spaces among the prior lines of interval?

Galileo: I would never wish to claim that a further interval or dimension is possible to pass to from the third dimension of depth.

Simplicius of Cilicia: I will read the portion of your work that agrees to this point, which is altogether most important to the Aristotelian cosmological argument. So far, I am glad that you are in agreement with our premises. You have your friend and mouthpiece Salviati state that, "it will necessarily follow that the one which is to define the breadth leaves the first at a right angle. That which is to denote the altitude, which is the third dimension, going out from the same point, also forms right angles and not oblique angles with the other two. And thus, by perpendiculars you have determined the three dimensions." You have Salviati continue, also in alignment with the Aristotelian premises, "and since clearly no more lines can meet in the said point to make right angles with them, and the dimensions must be determined by the only straight lines which make right angles with each other, then the dimensions are no more than three; and whatever has three has all of them, and that which has all of them is divisible in every way, and that which is so, is perfect."[8] Now, I commend your use of the syllogistic style of argument there, although, admittedly, you were discoursing about the Aristotelian cosmology, not the Copernican. Yet, at that point, the characters you have arguing for the Copernican world view agree with Aristotle thus far, is that right?

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[8] *Galileo. Dialogue Concerning the Two Chief World Systems.* Pg. 13-14

Galileo: That is right.
Simplicius of Cilicia: Well, I will pass over the fact that your character "Simplicius", who is supposed to be modelled after me, doubts the basic principles of the Aristotelian argument,[9] while the Copernican adherents state no qualms, and even are presented at the ones presenting and teaching the information to the Aristotelian. Then, their roles are reversed when contentions are made against the Aristotelian doctrine, so that Simplicius defends the scholastic view from the refutations of the other interlocutors.[10] We will continue with the Aristotelian argument from there, to discover your own, and presumably Salviati and Sagredo's, point of departure from agreement with us.
Galileo: That is well with me.
Simplicius of Cilicia: Then, since we have agreed that there is no other dimension of magnitude beyond the three, since what is divisible in three dimensions is divisible in all directions,[11] we need not take up arms in the argument about whether or not we can pass beyond body, termed also as volume, to a further kind, as we passed from length to surface, and from surface to body. And it will remain settled that body is complete magnitude. Aristotle says that, and you must agree, given what you said before, that we could only

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[9] *Galileo. Dialogue Concerning the Two Chief World Systems.* Pg. 14

[10] *Galileo. Dialogue Concerning the Two Chief World Systems.* Pg. 19

[11] *Aristotle. De Caelo*. I. 268a, 8-10

pass beyond the dimension of body in virtue of a defect of it, and that which is complete cannot be defective, since it extends in every direction.
Galileo: With which I am in agreement, both as I conceive the question now and as I presented Saviati and Sagredo as saying in the dialogue I wrote.

Simplicius of Cilicia: You admit, do you not, that nature is the principle of movement,[12] and that natural bodies and magnitudes are capable of movement, or locomotion?
Galileo: I admit that premise, yes.
Simplicius of Cilicia: Now, falling back to geometric propositions again, do you admit that of lines, the straight and circular are the only simple magnitudes, or in other words, that the only kinds of simple lines are the rectilinear and the circular?[13]
Galileo: I cannot disagree with your statement.
Simplicius of Cilicia: Then, tell me if you also agree that all movement in place, all locomotion as we call it, is either straight or circular or a combination of these two?[14]
Galileo: I also agree with that, yes.
Simplicius of Cilicia: Then, do you agree that revolution about the center is circular motion, while upward and downward movements are in a straight

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[12] *Aristotle. Physica*. III, 200b, 1

[13] *Aristotle. De Caelo.* II. 268b, 20-21

[14] *Aristotle. De Caelo.* II. 268b, 15-19

line, upward meaning motion away from the center, and downward meaning towards the center?[15]

Galileo: I agree, with the exception of rectilinear lateral motion, which I would rather not discount at this point of the argument.

Simplicius of Cilicia: Well, rectilinear lateral motion is, in our conception, a composite motion, as there is no body with a natural inclination to lateral motion, opposed to another element, and a natural place of rest in one lateral place opposed to another; which would, upon admission, grant four additional elements to the upward and downward motions of fire and earth, as there are four cardinal directions which lateral motion would require to be occupied by different substances. Now, none of the natural philosophers admit six elemental bodies, about which it would be necessary to ascribe the natural motions of four cardinal lateral directions along with the upward and downward motions of fire and earth. However, I suggest we leave off this point for the next segment, as we have not yet breached the span from geometrical to physical conceptions, upon which we will undoubtably come to that problem.

Galileo: Then see to it that we return to this point.

Simplicius of Cilicia: You have my word. So, in accordance with what was said before, as body found its completion in three dimensions, so its movement completes itself in three forms.[16]

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[15] *Aristotle. De Caelo.* II. 268b, 21-24

[16] *Aristotle. De Caelo.* II. 268b, 26-27

Galileo: That is not something I wish to contend with at this point of the argument.

Simplicius of Cilicia: Then to continue with the argument, we say bodies are either simple or compounded of such; and by simple bodies I mean those which possess a principle of movement in their own nature, such as fire and earth with their kinds, and whatever is akin to them.[17] Necessarily, then, movements also will be either simple or some sort of compound—simple in the case of the simple bodies, compound in that of the composite—and motion is according to the prevailing element.[18] Do you approve of that claim?
Galileo: Yes. So far as the argument has run its course, we Copernicans adopt all of the aforesaid premises even in our critique of the Aristotelians.

Simplicius of Cilicia: Supposing then, that there is such a thing as simple movement, and that circular motion is simple, and that both the movement of a simple body is simple and simple movement is of a simple body, then there must necessarily be some simple body which moves naturally and in virtue of its own nature with a circular movement.[19] Do you agree or disagree with that syllogism?

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[17] *Aristotle. De Caelo.* II. 268b, 27-30

[18] *Aristotle. De Caelo.* II. 269a, 1-3

[19] *Aristotle. De Caelo.* II. 269a, 3-7

Galileo: I agree that there is circular movement natural to some simple body, at the very least, and I and others also claim that circular movement is natural to Earth and to, indeed, all other bodies that aren't merely parts.
Simplicius of Cilicia: So far, we need not contend about what substance or substances have circular motion as their natural impulse, however, we are bound to contend over this point in due time. The argument so far only concludes that there is some body that moves naturally and in virtue of its own nature with a circular movement.
Galileo: Then we can deal with that later.

Simplicius: That would be more appropriate. Here is another premise about which I must ask your consent to. If you would say that unnatural or forced motion is the contrary of the natural motion of the same substance?[20]
Galileo: I would.
Simplicius of Cilicia: And would you also say that a thing can have no more than one contrary?[21]
Galileo: That is not a point I wish to argue about.
Simplicius of Cilicia: As, for instance, the case with upward and downward movements, which are natural and unnatural to fire and earth respectively?[22]
Galileo: Of the parts of fire and earth, do you mean?

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[20] *Aristotle. De Caelo.* II. 269a, 9-10

[21] *Aristotle. De Caelo.* II. 269a, 9-10

[22] *Aristotle. De Caelo.* II. 269a, 33-35

Simplicius of Cilicia: Yes
Galileo: Then I agree.
Simplicius of Cilicia: Then we agree. And the opposition between fire and earth and their motions is due to their naturally contrary positions (of rest) upward or downward along the same rectilinear lines?[23]
Galileo: That is clear.
Simplicius of Cilicia: And the unnatural or forced motion of earthen bodies is upwards, while the unnatural motion of fire is downwards?
Galileo: Yes, from our perspective.
Simplicius of Cilicia: Now, circular motion doesn't have as its contrary any rectilinear motion, does it? For we agreed that a thing can only have a single contrary, and further, that the unnatural and forced motion of a substance is motion in the contrary direction to that by which it moves in virtue of its nature towards its natural position of rest. Then since rectilinear motion towards and away from the center are contrary to each other, and natural and unnatural to earth and fire respectively, and a single thing can have only one contrary, then circular motion won't be contrary to either of the rectilinear motions, neither of fire away from the center, nor of earth towards the center.
Galileo: I follow the argument.
Simplicius of Cilicia: Then we again are led to the conclusion that there must be some simple body different from fire and earth, as well as from air and

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[23] *Aristotle. De Caelo.* II. 271a, 3-4

water, which naturally moves circularly, as fire moves upward and earth downward.
Galileo: I see how that conclusion is drawn.

Simplicius of Cilicia: Then also, neither will whatever body has the natural impulse of circular motion be the contrary of any of the simple bodies that have a rectilinear principle of motion. Can you deny that?
Galileo: I suppose not.
Simplicius of Cilicia: And I need not even pose the question whether or not the perfection and completeness of circular magnitudes in comparison to rectilinear magnitudes, and the vast distance of the revolutions of the celestial heavens from our mortal place on Earth, as well as the incommensurate beauty of the bodies carried around in circles, make reasonable our conviction in their divinity.
Galileo: Then I need not answer.
Simplicius of Cilicia: Well, in any case I will give you other questions to answer.
Galileo: Go on then.

Simplicius of Cilicia: Do you accept the following definitions? By the term 'heavy' I mean that which moves naturally towards the center. By the term 'light' I mean that which moves naturally away from the center.[24]
Galileo: From what center?
Simplicius of Cilicia: Never mind that. If you wish to quarrel about the position of the Earth as regards to the cosmos, that doesn't affect the use of the defined

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[24] *Aristotle. De Caelo.* II. 269b, 22-24

terms. For we both assume the term ‘heavy’ to apply to things that move towards the center of the Earth, regardless of its place at either the center of the cosmos or wherever you would place it under the Copernican view. And we both assume the term ‘light’ to apply to things that move naturally away from the center, however that may be conceived.

Galileo: Then I accept the terms heavy and light as you define them, at least for the course of the argument.

Simplicius of Cilicia: Now, everything which has a principle of motion and moves naturally upwards or downwards possesses lightness or heaviness or both—but not both relatively to the same thing,[25] for things are heavy and light relative to one another; air, for instance, is light relatively to water, and water is light relatively to earth. Is that agreeable to you?

Galileo: I don’t see why not.

Simplicius of Cilicia: But the body which moves in a circle doesn’t move either towards or away from the center, as circular motion was defined to be around the center, unlike the species of rectilinear motion. Didn’t we agree to that?

Galileo: We did.

Simplicius of Cilicia: Then the body which moves in a circle cannot possibly possess heaviness or lightness,[26] as those terms were agreed to designate bodies that move naturally towards or away from the center. Is that right?

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[25] *Aristotle. De Caelo.* II. 269b, 26-30

[26] *Aristotle. De Caelo.* II. 269b, 29-30

Galileo: I suppose that is right, yes.

Simplicius of Cilicia: Then, to move on to the next point. I ask now if you agree that everything that comes to be comes into being from a contrary and some substratum, and passes away likewise in a substratum by the action of a contrary into a contrary?[27]

Galileo: I have no reason to contend with the premise at this point.

Simplicius of Cilicia: And you would say, would you not, that the motions of contraries are contrary?[28]

Galileo: They must be.

Simplicius of Cilicia: If then, this body can have no contrary, because there can be no contrary motion to the circular, nature seems justly to have exempted from contraries the body which is ungenerated and indestructible.[29] Do you accept the conclusion?

Galileo: Well, I wish to contend with the premise that there can be no contrary motion to the circular. As to the conclusion—that the body that has as its nature circular motion is ungenerated and indestructible I would also like to contend with, on the basis that the premise from which it's drawn isn't clear.

Simplicius of Cilicia: First, it is clear to everyone that the two forms of rectilinear motion are opposed to one

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[27] *Aristotle. De Caelo*. II. 270a, 14-18

[28] *Aristotle. De Caelo*. II. 270a, 18

[29] *Aristotle. De Caelo*. II. 270a, 18-21

another by reason of their places; for up and down is a difference and a contrary opposition in place.[30] Then, we know that a single thing can only have one contrary. So, neither upward nor downward motion can be contrary to circular motion, as they are contrary to each other by virtue of opposition of place. We also agreed that the only forms of simple motion are circular and straight, the latter being further divisible into upward and downward. So, if the different forms of simple rectilinear motion are opposed to each other, and circular is the only kind of simple motion left without a contrary to another simple motion, for a simple motion couldn't be contrary to a composite motion, then it is obvious that circular motion has no contrary, especially since circular motion isn't divisible into species the way rectilinear motion is divisible into the upward and downward. And since we know that fire is the simple body that has the principle of motion—perhaps lightness—that leads it upwards, and that earth is the simple body that has the principle of motion—perhaps heaviness— that leads it downwards, we can be sure that the simple body that is neither endowed with lightness nor heaviness, and which moves circularly, is exempt from contrariety, since, again, it doesn't even possess an attribute like lightness or heaviness to be disposed thereby in opposition to some other simple body which possesses the contrary attribute.
Galileo: I accept that account, however might not the motions in different ways along a circle be contrary to each other?

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[30] *Aristotle. De Caelo.* II. 271a, 3-5

Simplicius of Cilicia: The first thing that should be said in response to your question is that, so long as you admit that circular motion isn’t contrary to any rectilinear motion, and we designate the various elements to different species of rectilinear motions, we are, nonetheless, dealing with the celestial bodies amongst themselves, not the elemental bodies, and have advanced to or past the lunar sphere. Now, your suggested question requires a solution, in any case.

If we take two points along a circle located at opposite ends of its diameter, and we suppose two ‘contrary’ rotations against each other from and towards those points, see what follows. It is important to note that the two points are considered as being opposed in terms of their place only by the diameter, since we invariably regard the distance between two points as the length of the straight line that joins them,[31] and we consider contraries to be the furthest points from each other along a continuum. A motion along a straight line to and from contrary ends has to stop and turn back before leaving one end and setting off towards the other, while a circular motion passes through both ‘opposing’ ends of an infinite number of diameters in a single round; for the circular motion goes from the same point towards the same point, and contrary motion was distinguished as motion from a contrary to its contrary. Thus, the primary difference between the two cases is that the two opposite ends of the diameter are passed through with a single continuous circular

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[31] *Aristotle. De Caelo.* II. 271a, 12-13

motion, whereas the rectilinear motion say, along the diameter which intersects the same circle, requires separate motions to go from one point to the other and to return to the first point again.
So, the formulation of the problem as one motion along a circumference as from a to b, and another, supposed as contrary to the first, as from b to a, will render the term ‘contrary’ somewhat meaningless, if described as such—as the first motion, from a to b, will, without pausing and turning around with a second motion, also proceed from b to a; and the second motion that we say goes the other way from b to a, upon passing a, will proceed from a to b. So, in a sense, they will both be going from a to b and from b to a, in a single motion, without turning back with a second motion. There is, admittedly, a sense in which the motions are different, yet their difference wont hold to the requirements of the definition of contrarieties. For circular motion is primarily regarded as going from the same point towards the same point, and contrary motion was distinguished as movement from a contrary to its contrary.[32] That is to say that circular motion can have no contrary, neither rectilinear motion, nor circular motion in the other direction along the same circumference.

Galileo: I accept the argument with hesitation and reserve.
Simplicius of Cilicia: Then we are at liberty to return to the conclusion which was postponed until the premise in question was clarified.

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[32] *Aristotle. De Caelo.* II. 271a, 20-23

Galileo: I suppose so.
Simplicius of Cilicia: The syllogism was as follows—If then, this body can have no contrary, because there can be no contrary motion to the circular, nature seems justly to have exempted from contraries the body which is ungenerated and indestructible. Perhaps you would prefer if I garnish the argument with a rhetorical charm, and dress it up in a fine Tyrian cloak of speech. Our theory of the eternality of the heavens seems to confirm the phenomena and to be confirmed by the account we inherited from our ancestors. For all men have some conception of the nature of the gods, and all who believe in the existence of gods at all, whether barbarian or Greek, agree in allotting the highest place to the deity, surely because they suppose that immortal is linked with immortal and regard any other supposition as impossible. If then there is, as there certainly is, anything divine, what we have just said about the primary bodily substance was well said. The mere evidence of our senses is enough to convince us of this, at least with human certainty. For in the whole range of time past, so far as our inherited records reach, no change appears to have taken place either in the whole scheme of the outermost heaven or in any of its proper parts. The name, too, of that body seems to have been handed down right to our own day from our distant ancestors who conceived of it in a fashion which we have been expressing. Implying that the primary body is something else beyond earth, fire, air, and water, they gave the highest place that name of *aether*, derived from the fact that it 'runs always' for an eternity of time.[33]

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[33] *Aristotle. De Caelo.* II. 270b, 3-25

Galileo: I am under the impression that I have been led to admit more than I would wish. For, while I thought you were asking about mathematical propositions, I was led to admit to a great deal more than I would like to about physics. And, all the while you barely let me speak, besides in either affirmation or denial. I might have as well simply nodded my approval or shook my head in disapproval, rather than say anything. I would like to take back some of the admissions I made you your questions. For, at the time, I didn't see the direction you were leading me through the argument.

Simplicius of Cilicia: That is why I took the time to ask if you agreed that the principles of magnitudes and bodies were part of the science of nature. And I explained how the principles of a science were useful in the investigation of that subject matter. I'm afraid you cannot take back your prior admissions after having already given your approval. I also made a point to say that I wanted you to adhere to the rules of argument, which you will forsake by taking back your admission to any of the premises. If you refuse to answer in the manner that dialectic requires, and you change your answers to prior questions, I can have no part in conversation with you. I see that you wish to give a speech, rather than ask and answer questions with me. Also, I would rather not give up the leading position of questioner quite yet, nor to exchange speeches with you, but I would like to hear what you find problem with after going through the discussion thus far.

Galileo: Now that I see where the argument was heading, I find problem with more than a few propositions you compelled me to agree to. Somehow, I would not change my answer to much of the mathematical propositions you asked me about, yet somewhere along the way, wherever those were transfigured into physical propositions, I would rebuke my approval.

Simplicius of Cilicia: You agreed, however, that the principles of magnitudes and bodies were a part of the science of the motion of magnitudes and bodies, did you not?

Galileo: I did, however, I expressed reserve about the applicability of geometrical terms in the course of physical investigations.

Simplicius of Cilicia: And I also expressed reserve about the lack of precision in the physical sciences, yet not in the sense that we used any of the geometrical terms throughout the argument, which I doubt contained anything indefinite in their use. I, for my part, wasn't doubting the use of such simple terminology, and what is more, there isn't a way to exchange them for non-geometrical terms, which is a telling factor about how physics is bound up with geometry.

Galileo: I suspect you avoided reference to the significant differences between the Copernican and Aristotelian cosmologies, in order to gain my agreement to conclusions that I unexpectedly was made to agree to. If I may voice my disapproval, I will explain.

Simplicius of Cilicia: Go on.

Galileo: The premises were agreeable, and I know not which ones I would dispute with, however, there was a leap from those, for the most part, mathematical premises to conclusions of physics, which took me off guard, so that I felt the need to agree to them out of preferring consistency to the argument, all the while ignoring my wish to disagree with them at face value. It is for the sake of some of the physical conclusions drawn from mostly mathematical premises that I said I would change my answers to some premises. For, the mathematical propositions themselves I consider to be true, yet their syntheses into conclusions of the science of nature I doubt.

And no one, Simplicius, would be able to controvert these statements of yours. But, all the same, those who occasionally hear philosophers argue thus feel in this way—they think that owing to their inexperience in the game of questioning and answering they are at every question led astray a little bit by the argument, and when these bits are accumulated at the conclusion of the discussion mighty is their fall and the apparent contradiction of what they said at first,[34] or, as in this case, great is their perplexing and unexpected admission of something which they would have before refused. I would like to proceed with my own account of the Copernican point of departure from the Aristotelian view, or else, regardless of my admission to unexpected conclusions against my initial opinion, the continuity of the course of the argument will be unclear and disrupted, both to me and to the listeners.

Simplicius of Cilicia: Alright, you may proceed.

Galileo: I admit the argument up to and including the conclusions that the world is a body endowed with all dimensions, and therefore perfect. And I add that as such it is of necessity most orderly, having its parts

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[34] *Plato. Republic.* VI, 487a

disposed in the highest and most perfect order amongst themselves.[35]
Simplicius of Cilicia: Very good.
Galileo: This principle being established then, it may be immediately concluded that if all integral bodies in the world are by nature movable, it is impossible that their motions should be straight, or anything else but circular; and the reason is plain and obvious. For whatever moves straight changes place and, continuing to move, goes ever farther from its starting point and from every place through which it successively passes. If that were the motion which naturally suited it, then at the beginning it was not in its proper place. So, then, the parts of the world were not disposed in perfect order. We are assuming them, however, to be perfectly in order; and in that case, it is impossible that it should be their nature to change place, and consequently to move in a straight line. So, I say that it is impossible that anything should have by nature the principle of moving in a straight line.[36]
Although straight lines are somewhat indefinite and lack the completion that characterizes circular lines, someone might say that nature has, so to speak, arbitrarily assigned to them some terminus and has given her natural bodies natural instincts to move towards that end. And I shall reply that this might perhaps be fabled to have occurred in the primordial

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[35] *Galileo. Dialogue Concerning the Two Chief World Systems.* Pg. 19

[36] *Galileo. Dialogue Concerning the Two Chief World Systems.* Pg. 19

chaos, where vague substances wandered confusedly in disorder, to regulate which nature would very properly have used straight motions. By means of these, just as well-arranged bodies would become disordered in moving, so those which were previously badly disposed might be arranged in order. But after their optimum distribution and arrangement, it is impossible that there should remain in them natural inclinations to move any more in straight motions, from which nothing would now follow but their removal from their proper places; which is to say, their disordering.[37]

We may therefore say that straight motion serves to transport materials for the construction of a work; but this, once constructed, is to rest immovable—or, if moveable, is to move only circularly.[38]

Simplicius of Cilicia: When you use the term ‘the world’ do you mean the heavens or the Earth? For, as you know, the term world is used in different senses—to refer to the Earth, or to refer to the whole which includes both the heaven and Earth, or perhaps by figures like Empedocles in reference to the ‘whirling’ motion of the heavens.

Galileo: I mean by the term ‘world’ the whole which comprises both the heavens and the Earth, and I refer to all natural bodies within the whole.

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[37] *Galileo. Dialogue Concerning the Two Chief World Systems.* Pg. 20

[38] *Galileo. Dialogue Concerning the Two Chief World Systems.* Pg. 20

Simplicius of Cilicia: And when you speak about the production of order from chaos, do you also refer to the whole, or to the Earth and the elemental bodies beneath the lunar sphere?
Galileo: I speak of ‘order from chaos’ in reference to the whole, including both celestial and elemental bodies.
Simplicius of Cilicia: Yet it is also true that in refusing the possibility of movement in a straight line you have in your mind the elemental bodies, such as fire and earth, which are by others claimed to have rectilinear motion—the contradictory proposition that you deny. Is that right?
Galileo: Yes, that is my intended meaning, of course.
Simplicius of Cilicia: Tell me, do you consider the establishment of order out of chaos as generation, as I, myself, do. Or do you suppose that it is possible to avoid prefixing the term ‘generated’ before the phrase ‘out of chaos’, when discussing the ‘production of order ‘from the proclaimed prior disorder.
Galileo: I consider order to have been ‘generated’ out of chaos, yes, and that is my intended meaning.

Simplicius of Cilicia: You also claim that after the supposed ‘generation’ of order out of chaos, at which point the optimal distribution and arrangement of the parts of whole cosmos were set in place, it would be impossible for the parts to have a principle of straight movement.[39] Is that the claim you make?

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[39] *Galileo. Dialogue Concerning the Two Chief World Systems*. Pg. 19-20

Galileo: Why yes, for only circular motion is preservative of the order of the whole cosmos. I also said that upon completion of the established order out of chaos, the only options for the parts and the whole would be rest or circular movement, since rectilinear motion would then only serve to displace them from their proper places.[40]

Simplicius of Cilicia: Then you either refuse the generation of elemental bodies, or you claim that the rectilinear movement of elemental bodies is part of the prior chaos, or you claim that the generation of order out of chaos refers to the generation of the circling heavenly bodies out of the lower sphere of elemental bodies that have principles of straight motion. One or two or all those propositions must be your position. So, tell me which of the three positions you hold.
Or if you wish I will refute each of them in turn… as you hesitate to make a response, I will go through the impossibility of each of them in turn. However, I would like to address your claim directly beforehand.

There is much to say about such a radical claim as you propose. So, first I will walk you through the steps of Aristotle's and my own argument for the necessity of rectilinear motion for the conditions which make generation possible.
Galileo: Go on with the argument.
Simplicius of Cilicia: I will begin from Aristotle's wonderous question, why the whole body of the

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[40] *Galileo. Dialogue Concerning the Two Chief World Systems*. Pg. 19-20

heavens is not of the same character as the outermost sphere, the firmament of fixed stars.[41] I will ask your response. So, he begins by drawing out the consequences that would have to result if the outermost sphere, the firmament decorated with fixed constellations, were the only principle of motion, and if no other sphere within that possessed its own principle of motion, so that all the gradations of lower bodies were carried around by the diurnal movement of the outer sphere. So, I ask you, if a given sphere is rotated, are not all the contained parts and mass of the whole sphere carried around with the outer surface, so that even the center-most globe turns with the same rotation, although perhaps a magnitude-less point at the center of the innermost sphere would be exempt from rotating through a circumference of places— since it would have no magnitude— in alignment with the outermost circumference?

Galileo: Yes, that is clear.

Simplicius of Cilicia: Then, wouldn't you say that a single movement of the whole heaven, without any other separate movement of any of the layers encompassed by the outermost sphere, would necessitate an identical relation of the elements of bodies to one another?[42]

Galileo: I suppose so, yes.

Simplicius of Cilicia: Then isn't more than one circular body necessitated and required to account for

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[41] *Aristotle. De Caelo.* II. 3. 286a, 11-16

[42] *Aristotle. De Caelo.* II. 3. 286b, 2-4

the fact of generation,[43] as well as for each of the planetary motions through the zodiac, or, in other words, through the belt of the outermost sphere of fixed constellations—for the planetary spheres each have their own separate motion, different from the more rapid daily revolution of the outermost sphere which carries them all around with it, so that each planet is carried around with the turning motion of the whole outer sphere and also, by a separate motion, transits the circumference of the same outer sphere of fixed constellations—and these separate motions of the planetary spheres would not be possible to account for without the admission of the movement of more than one circular body?
Galileo: Yes, there must be separate motions for more than one circular body to account for both generation and the course of each planet through the zodiacal signs.
Simplicius of Cilicia: Or else, as we agreed, the elements and bodies contained in the outermost sphere—if that were the only principle of motion—would be indifferently homogenous in identical relation to one another. Right?
Galileo: Yes, as we said already.

Simplicius of Cilicia: Then we agree that at least additional circular motions besides that of the outermost sphere are necessary to account for generation. Now, it is my place to prove the necessity of rectilinear motion to, likewise, account for generation. That is my challenge as you have set it before me, having denied the possibility of rectilinear motion both in general and in a well-ordered cosmos. As additional, or multiple, circular motions were agreed upon as required to account for generation, I suggest that rectilinear motion is not only required for accounting for the fact of generation but is further involved with generated things themselves.

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[43] *Aristotle. De Caelo.* II. 3. 286b, 4-6

So, Galileo, even if you deny that the elemental bodies from which generated things are composed of don't adhere to rectilinear motion, upon which such a preposterous claim I have only contempt, you must admit this—that generated composite things are synthesized from the elemental bodies, earth, water, air, and fire. Is that agreeable to you?

Galileo: Of course I agree with that.

Simplicius of Cilicia: The next step is to inquire into the path that the elemental bodies take in combining to form composites. I doubt you suppose that those elemental bodies intermingle in the formation of composites along some circumference. Is it not altogether more appropriate to say that the contact between earth, fire, water, and air must take place along rectilinear lines? For, otherwise, one elemental body would have to encircle the next, and so on—and although the elemental spheres are enclosed within each other's circumference, when considered as a whole—the contact of the parts of air, water, earth, and fire would be more reasonably considered as striking against one another along rectilinear lines, instead of as thought of as a sphere of fire containing a sphere of air, and that of water, and that of earth, in the course of their contact and intermixture. Or do you think that the elements intermingle and synthesize into compounds through motion along a circumference or

through one containing the other within its circumference, and the other containing the next, and so on, rather than their striking against each other in the course of rectilinear motion, in any direction?
Galileo: I would have to further consider the question.

Simplicius of Cilicia: Then in the meantime, consider this. Since we are investigating whether generation involves and depends upon rectilinear motion, we ought to turn to the consideration of generation and corruption themselves. For one, those are contraries, and their contrariety is between two points of time, one before, and the other after, which themselves take place along a rectilinear continuum. So, the whole course of generated and corrupted bodies runs from a beginning to an end along a line conceived of time. Now, regardless of speculation about whether or not time is circular and events in time recur circularly, the course of time spanned by a generated and corrupted body, having a single point of origin from which it proceeds to a single point of departure, would more properly be thought of as a rectilinear motion rather than circular motion through time. So, is it not reasonable that generation and corruption are themselves contraries, and that they are always placed along a time line bounded by contrarieties?
Galileo: Yes, however that doesn’t go so far as to show that there is a natural principle of rectilinear motion.
Simplicius of Cilicia: We will get to that point soon enough.
Galileo: Then proceed.
Simplicius of Cilicia: Are not generated bodies subject to the contrarieties of growth and decay, or increase

and decrease, hot and cold, moist and dry, of which states they pass back and forth from in alteration—and isn't change restricted to the back and forth path of such alterations, with the exception of some kinds of local motion?
Galileo: Yes

Simplicius of Cilicia: Then, supposing all that, and contrasting alteration of all those types to the course of circular motion, which returns to the same point it left in a continuous movement, and designating alteration of opposite states as akin to motion back and forth along a rectilinear line, which must stop at one end—say, upon becoming moist—before setting off for the other end— towards, say, becoming dry—without the possibility of returning to the first point in a single continuous motion, but must be severed into two separate motions back and forth; then, given that generated bodies are subject to various forms of alteration between contrary states, and that such qualitative and quantitative changes and alterations are akin to motion back and forth along a straight line, is it not reasonable to conclude that generated bodies should have rectilinear movements?
Galileo: I would rather not determine the movement of generated composite bodies by considerations of parallels found in their qualitative alterations.

Simplicius of Cilicia: Well, considering that I am only attempting to argue for the existence of a principle of rectilinear motion among natural bodies, I should say that I find it surprising that, if there were no principle of rectilinear motion in nature, there should still be analogous parallels amongst generated bodies. I suppose it would be better to abandon this specific argument for the time being, and to return to where we left off before. For, I will attempt to find a different way to prove that there, indeed, is a natural principle of rectilinear motion which generated bodies are subject to. Or, at the very least, I will show the inconsistencies in your derived claim about the absence of such a principle of straight movement on the basis, as you claim, of the 'order out of chaos' myth. For there are other tracks of the argument about your same claim—that there is no principle of rectilinear movement amongst the natural bodies—that can be reverted to, since I cannot convince you of the presence of such a natural principle of motion in my most recent attempt.
Galileo: Then let us return to where we left off.

Simplicius of Cilicia: You were saying that, according to the major premise, the world is perfectly orderly, and to the minor premise, that rectilinear motion would only displace things that were already established in due order, there is no principle of rectilinear motion amongst natural bodies. Were you not?
Galileo: I was.
Simplicius of Cilicia: Then I responded that if you deny that there is a principle of rectilinear motion set

over the elemental bodies and their compounds, then you must either refuse the generation of elemental bodies, or claim that the rectilinear movement of elemental bodies is part of the prior chaos, or claim that the generation of order out of chaos refers to the generation of the circling heavenly bodies out of the lower sphere of elemental bodies that have principles of straight motion. Now, I think these three propositions are bound up with each other, and that if we select one, we will in due course stumble upon the others.
Galileo: Take them up in whichever order you wish.

Simplicius of Cilicia: Then, according to your own statement, that rectilinear motion can only have a place in nature until order is established (out of the prior chaos) and the parts have all been brought back to their due places, would you say that the rectilinear motion of elemental bodies and their compounds is part of the prior chaos?
Galileo: I should say that, yes.
Simplicius of Cilicia: You said before, didn't you, that order was 'generated' out of chaos, and that such a process was undoubtably what we primarily mean by 'generation'?
Galileo: I did say that, and unerringly.
Simplicius of Cilicia: And the 'generated order' out of the prior disorderly chaos you said referred to the establishment of circular motions of bodies, did you not?
Galileo: I did, and for the reason that, of movement, circular is the only kind that preserves and keeps order.

Simplicius of Cilicia: Then you ascribe generation to the circular heavenly bodies, while you ascribe to the elemental bodies and their composites a place amongst the prior chaos. Would you say that?
Galileo: Yes

Simplicius of Cilicia: I wonder if you are backwards or upside down or inside out. Your conceptions remind me of the appearances of constellations as seen from latitudes south of a hundred gated Thebes, which are from there unrecognizable to northerners. One would think they have journeyed to the underworld. For you call the celestial bodies that move circularly ‘generated’ in so far as order was generated out of chaos, and the only motion, as you say, that preserves order is the circular. While you must call the elemental bodies and their compounds ‘ungenerated’, since, as you said, there is no principle of rectilinear motion in nature once order is produced, and again, by order you mean what is ‘generated’ out of chaos; while you also said that the rectilinear motion of elemental bodies and their compounds is part of the prior chaos. Are those all points you would make?
Galileo: Yes, they are. And along with my admission of the rectilinear motion of elemental bodies and their compounds as ungenerated, I also admitted that their only place in nature can be amongst the prior chaos, and, also, that the generation of order out of chaos refers to the generation of the circling heavenly bodies out of the lower sphere of rectilinearly moving elemental bodies. And so, there is no inconsistency in my train of thought, is there? For, all this you have unraveled from my first statement, that, “by assuming the parts of the whole cosmos to be perfectly in order,

it is impossible that it should be their nature to change their place from their natural stations, and consequently I say that it is impossible that anything should have by nature the principle of moving in a straight line."[44] As to your other statement, I should remind a staunch Aristotelian like yourself that Aristotle argues that what we call the southern hemisphere and the southern pole is upward and faces the top of the cosmos, while the northern hemisphere and the northern pole is downward and faces the bottom of the cosmos.[45]

Simplicius of Cilicia: We will continue to investigate your consistency or inconsistency. As to your reference to Aristotle's claim about the southern hemisphere facing towards the upper end of the cosmos, that is only for the turning of the outermost sphere, which, if you lay on your back with your head facing the northern pole, admittedly seems to revolve from left to right, yet the opposite is the case if you lay down with your head facing towards the south. However, the opposite is the case with the five planets and the Sun and Moon, which, to us northerners, move from right to left, as a right-handed person throws.[46] We had better return to the argument, though, and leave off with this digression. I think you will appear

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[44] *Galileo. Dialogue Concerning the Two Chief World Systems.* Pg. 19, 20, 31, 32, 33, 34, 35, 37, 38, 39, 45, 46

[45] *Aristotle. De Caelo.* II. 2, 285b, 14-15

[46] *Aristotle. De Caelo.* II. 2, 285b, 29-35

to yourself to be backwards, upside down, or inside out in what follows.
Galileo: Then continue with the investigation.

Simplicius of Cilicia: You say that circular motion is a product of generation while rectilinear motion is ungenerated, as you call rectilinear motion that which, as from the primordial chaos, circular motion was generated from, as order. Is that right?
Galileo: Yes, that is right.
Simplicius of Cilicia: You, then, think the celestial bodies were generated from the elemental bodies of the lower sphere?
Galileo: That follows.
Simplicius of Cilicia: Under analysis it appears that you hold as a premise the statement that the better can have as their cause the worse. Do you hold that to be true? Or else you would never attribute the elemental bodies of the lower sphere as the cause of the celestial bodies of the upper spheres.
Galileo: I must agree.
Simplicius of Cilicia: Beyond that, you are the only person with such madness to think of generation as not belonging to the sphere of elements and composites of those. Besides you, there isn't a single person babbling in any town square throughout Europe that refuses to consider generation as referring to the composites produced from elemental bodies. So, I insist that you answer this. What else besides composites produced from combinations of elements could generation indicate?
Galileo: I told you. As I have been using the term 'generation' in the course of the argument thus far, I have had in my mind the meaning of the production of

order. For, as you look to parts and the gathering of scraps into menial productions, I have my eye to the whole and the generation of the whole cosmos.

Simplicius of Cilicia: Do you not realize that the term ‘generation’ seems to be wholly restricted to be used as to indicate the production of composites from combinations of elements. The same goes for the term given to the products of generation, that is, ‘composites’, as also for the term given to the materials from which those a produced, called ‘elements’. The meaning of these terms you hastily ignore in your vulgar dialect. One ought to wonder at your choice not to publish your written works in the Latin tongue, as to discover what sort of audience you catered to. For, no man of letters would care to pick up a book that was written in such vulgar vernacular.
Galileo: You need not personalize your assault.
Simplicius of Cilicia: Then I’ll broaden my assault and, if you won’t answer my question about the use of such terms as ‘generation’, ‘composites’, and of predicates such as ‘the combinations of elements’, I will ask about your master Copernicus, if he was not only born in Poland to Polacks, or if he was educated there by them as well?
Galileo: I will answer your question about the use of terms. When speaking about the generation of the whole world, rather than of a part, there is a difficulty in keeping to precision of meaning, much like we discussed about the application of geometrical terms to the physical sciences.
Simplicius of Cilicia: Then, we can safely agree that one or the other of us is utterly backwards, upside

down, and inside out. As for me, I speak of generated things as composites produced from combinations of elements. And I assume that you speak in that way as well when you aren't reverting to the argument at hand.

Galileo: When discussing the various parts of the world and their transfigurations I use those terms quite how you define them.

Simplicius of Cilicia: And I suppose that you think they really apply when you say that order was generated from chaos. For no one else actually interprets that mythos, that 'order was generated from chaos', attaching the meaning of chaos the elemental bodies of the lower sphere which combine to produce generated things on the surface of the Earth; then, interprets the 'order' which was generated from chaos as meaning the stars and luminaries in their orbits, confusing both into your proposition that 'the celestial bodies were generated from the combinations of bodies of the lower sphere of elements'.

Galileo: Such affirms only the ingenuity of my theories.

Simplicius of Cilicia: We can move on to another argument that should prove more fruitful and profitable than the current argument.

Galileo: Go on.

Simplicius of Cilicia: Let us consider what shape is primary amongst nature.[47] For upon finding that out, we will have some leverage as to the problem of the question about whether bodies that are subject to rectilinear motion can, as you say, be the cause of bodies that have circular motion, which I doubt. So, I ask you if you agree that rectilinear figures are bounded by more than one line?[48]

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[47] *Aristotle. De Caelo.* II. 4. 286b, 12

Galileo: Of course. Three straight lines are the minimum that can encompass a rectilinear figure, as the mathematicians affirm.

Simplicius of Cilicia: Yet do you agree that curvilinear figures are bounded by one single line?[49]

Galileo: Yes, circular figures are encompassed by a single line.

Simplicius of Cilicia: Do you agree that the simple is prior to and more complete than the complex, and that the few are prior to and more complete than the many, and that one is more prior to and complete than a multitude?[50] Or do you think that the more complex can be thought of as prior to and more complete than that which is more simple?

Galileo: I agree that the simple is more prior and complete, and the complex more posterior and incomplete.

Simplicius of Cilicia: Then does it follow that the circle is most prior, complete, and primary amongst figures?[51]

Galileo: I would not dare to argue on that point.

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[48] *Aristotle. De Caelo.* II. 4. 286b, 15

[49] *Aristotle. De Caelo.* II. 4. 286b, 15

[50] *Aristotle. De Caelo.* II. 4. 286b, 15-17

[51] *Aristotle. De Caelo.* II. 4. 286b, 17, 22

Simplicius of Cilicia: Then, is not the sphere most prior, complete, and primary amongst solids? For it alone is embraced by a single surface, whereas rectilinear solids are bounded by several, at least four, surfaces.[52]

Galileo: The sphere is, indeed, most prior, complete, and primary amongst solids.

Simplicius of Cilicia: Here is something else to solidify your conviction. Have you noticed that those who divide bodies into surfaces or planes, and generate them out of surfaces or planes, seem to bear witness to the to the truth of this. Alone amongst solids they leave the sphere undivided, as not possessing more than one surface; for the division into surfaces is not just dividing a whole by cutting into its parts, but division into parts different in form.[53] Then, according to a second method of division, of the division of solids into solids rather than of the bounding surfaces of solids into plane figures, there is a further description to be provided about the indivisibility of spheres. By being bounded by a single surface, the sphere does not naturally admit division into two hemispheres—I say that spheres are not divisible in the way that octahedrons are naturally divisible into two pyramids, or in the way that cubes are divisible into six pyramids—I don't mean the more perfect kind of pyramids whose base is a triangle equal to each of their other surfaces, and which are called tetrahedrons, but the kind of pyramids whose base is a

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[52] *Aristotle. De Caelo.* II. 4. 286b, 22-25

[53] *Aristotle. De Caelo.* II. 4. 286b, 26-31

square, like those wonderous monuments around the area of Memphis in Egypt, in proximity also to Heliopolis; nor how icosahedrons are divisible into twenty tetrahedrons, or, by a different cut, into three solid figures with a pentagon as the base of each and five equilateral triangles that meet at each of their vertices, with the admitted qualification that two remaining triangles would have to be disregarded, rendering the division of the icosahedron only strictly divisible into tetrahedrons according to that mathematical method of division. That is a long and about way to show that the sphere is not divisible, strictly speaking, according to mathematics, which was a topic we only brought up to exhibit that spheres are more prior, complete, and primary than rectilinear solids. Hopefully, this mathematical diversion wasn't a distraction from the premises and what will follow.
Galileo: I don't think any of that diverts my attention from the argument.

Simplicius of Cilicia: There is, however, a risk in losing the aim of a train of thought by pursuing some tangent. So, to get back to the argument, we agreed that spheres are primary among solid figures and that rectilinear solids are posterior. Now, you say that the only use nature can have for a principle of rectilinear motion is during the primordial chaos. You also say that order was generated from that primordial chaos, presumably from rectilinearly moving bodies. Then you say that the order which was generated from chaos must have been the order of circular motion that we observe the celestial bodies to adhere to. That then, is to say, according to your argument, that the bodies that have circular motion in the heavens were generated

from bodies that have rectilinear motion among the lower spheres. I, on the other hand, argue for the contradictory hypothesis, about which I will take up again. We left off at the last point of agreement, that circles and spheres are more prior, complete, and primary to rectilinear figures and solids. From that, does it not follow that circular motion is also more prior, complete, and primary than rectilinear motion?
Galileo: I will admit that point also.
Simplicius of Cilicia: Well, the celestial spheres rotate circularly, do they not?
Galileo: They do.
Simplicius of Cilicia: And if there is such a thing as a principle of rectilinear motion in nature, that could only apply to the elemental bodies and their composites in the lower spheres. Will you agree to that much?
Galileo: As the statement was qualified, yes.
Simplicius of Cilicia: Then, does it not follow that the circular movement of the celestial bodies is more prior, complete, and primary than the motion of elemental bodies and their composites?

Galileo: Given what was said before, that follows.
Simplicius of Cilicia: Now, is it possible to account for the more prior, complete, and primary by tracing their cause to things more posterior and incomplete? Or do you say with me that the cause must exceed the effect in purity of whatever quality is transmitted. What I mean is this—if a quality of heat or whiteness, or anything else, is transmitted from one object to another, the object which is the cause of the same quality in another object will always exceed the

effected object in purity and strength of the effectually transmitted quality. Do you agree with me?
Galileo: I must agree with you on that point. For, obviously a fire has a greater degree of heat than that which it causes in an object that receives warmth due to proximity. That is your meaning, right?
Simplicius of Cilicia: That is my meaning. So, then you must also agree that the more prior, complete, and primary is the cause of the more posterior and incomplete, and not the other way around.
Galileo: Yes, that is plain enough.
Simplicius of Cilicia: Well, we agreed that circular motion is more prior, complete, and primary than rectilinear motion, since we previously said that circles themselves are more prior and complete than rectilinear figures.
Galileo: That was said.
Simplicius: Then, being more prior, complete, and primary, won't the celestial bodies that move circularly be the cause of the elemental bodies that move rectilinearly, since the more prior, complete, and primary must be the cause and not the effect of the more posterior and incomplete?
Galileo: I am compelled to give my approval.
Simplicius of Cilicia: Won't, also, it be impossible for the elemental bodies and their composites that move rectilinearly to ever be thought of as the cause of celestial bodies that move circularly?
Galileo: Again, I have to approve of the conclusion drawn, regardless of my personal convictions, at least for the sake of the argument.

Simplicius of Cilicia: But according to your account of the world, rectilinear motion corresponded to the primordial chaos before order was generated, and an order which, you say, is restricted to circular movement, having no place for rectilinear motion. And now look how your inconsistencies emerge. In the scope of this argument, there can't even possibly be a doubt that the term 'generation' can only be applied to bodies that move rectilinearly and can never be applied to celestial bodies that move circularly. Neither can there be a doubt that the elemental bodies and their composites can be prior to the celestial bodies that revolve in perfect circles, nor that rectilinear motion was prior to circular motion, as chaos to order. And I will restrain myself from continuing with this flogging of you, so that we might sort out this confusion about chaos and order, as that was the basis of your argument, and about which you don't stand alone, but with a seemingly limitless crowd, or rather horde, of others like yourself.

Galileo: I must say, Simplicius, that the combination of the pressure from the Roman authorities that summoned me here and oversee our discussion, with your method of argument provide conditions which restrict my defense of the Copernican cosmology. If we were freely discussing this subject at our leisure, I would be more able to contend with your arguments. Know that I have plenty more to say about these problems.

Simplicius of Cilicia: And I'm sure that if you stripped me of my method of argument, and refused to say simply whether you agree or disagree with each premise, and spun off on a speech in response to my questions, especially if you had others to compound interest in the confusion, so that the topic wouldn't sit still, and any random one of them might interject with their ‘opinion’, I would be as much at a loss as you are now in convincing you and your friends in your usual habits of conversation. Now, let us return to where we left off with the argument. I wish to prove that chaos couldn’t have preceded order, and that the primordial motion before generation was not chaotic, and in turn, that order could never have been generated from chaos.

Galileo: I would like to hear an attempt at such an argument.
Simplicius of Cilicia: That was the hinge on which our disagreement rested, wasn’t it?
Galileo: It was.
Simplicius of Cilicia: First tell me if you agree that circular motion goes from and towards the same point—[54]that is, it has the same point as its beginning and end of motion, or, in other words, advances towards the same place which it left, in one continuous motion, without stopping to turn back to its point of origin?
Galileo: I agree with your statement.
Simplicius of Cilicia: Then tell me if you agree that rectilinear motion begins from one point and ends at a different point?[55]
Galileo: I agree with that as well.

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[54] *Aristotle. De Caelo.* I. 4. 271a, 20-21, *Physica.* VIII. 8. 264b, 17-18

[55] *Aristotle. Physica*. VIII. 8. 264b, 18-19

Simplicius of Cilicia: The you must also agree that rectilinear motion, having different places as its beginning and end, has to stop, and set off on a second and separate motion, if it is to return to the place it began its previous motion from?[56]
Galileo: I also agree with that.
Simplicius of Cilicia: And I assume you agree that rectilinear motion cannot be infinite in duration, since the beginning and end points of motion along a straight line are necessarily different and separate?
Galileo: Yes.
Simplicius of Cilicia: Then we might say that circular motion occurs from and to its place, whereas rectilinear motion is motion from its place to another place.[57] Is that fair?
Galileo: In my consideration, that is a fair thing to say.
Simplicius of Cilicia: Do you agree that circular motion is infinite in duration, since the beginning and the end of circular motion are the same place, and by one continuous motion it goes from and returns to the same point on the circumference?
Galileo: Yes

Simplicius of Cilicia: Now, which of the two do you consider to be more orderly—rectilinear motion which has as its places of beginning and end two different points, and which must take up a second motion to return to the same place it set off from during its first motion, in which a returning motion is broken from the preceding motion, or circular motion, which has as the beginning and end of the completion of its course along a circumference the same point, and which returns to the place it began from with a single continuous movement?

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[56] *Aristotle. Physica*. VIII. 8. 261b, 33-34

[57] *Aristotle. Physica*. VIII. 8. 264b, 17-19

Galileo: I consider circular motion to be more orderly.

Simplicius of Cilicia: As do I. Now, of which of the two do you consider to require an account of their origin, the circular or the rectilinear? Recall that we agreed that motion along a straight line is necessarily finite—since any place from which it has arrived from is where it must have stopped and broken the course of its previous motion, and neither can it return to any beginning of motion without stopping and then advancing back in a second and different motion—and that motion along a circular line is infinite in time, since the beginning and end of its motion are the same place, and it returns to its own place by the same continuous motion which it set out with. What is your answer?

Galileo: I say that the rectilinear kind of motion requires an explanation of its origin more so than that of circular motion.

Simplicius of Cilicia: And would you say that circular motion, being capable of infinite duration, doesn't require an account of its origin? For an origin implies a beginning, and an infinite duration in time has no beginning. Or at least, do you see that we would amount ridicule by pointing to rectilinear motion in our account of the origin of circular motion, and that we are required to point to circular motion to account for the origin and beginning of rectilinear motion?

Galileo: I agree with both of your statements—that circular motion must not require an account of its origin, since it has no beginning in time, and that we are required to account for the beginning of rectilinear motion, to which it is reasonable to point to circular motions.

Simplicius of Cilicia: We have agreed then that circular motion is more orderly, capable of infinite duration in time, and therefore doesn't require an account of its origin, and that rectilinear motion is less orderly, and requires, along with its beginning in time, an account of its origin. Have we not?
Galileo: We have.
Simplicius of Cilicia: Then, circular motion cannot have been posterior to and dependent upon rectilinear motion, and rectilinear motion could not have been prior to and the cause of circular motion, as must be the case since rectilinear motion is the one that requires an account of its origin, and since circular motion had no beginning in time.
Galileo: That is clear.
Simplicius of Cilicia: Then you, along with so many others, must admit that order was not generated from chaos.
Galileo: I fear you are right.

Simplicius of Cilicia: Well, dispose of the terms order and chaos momentarily, and also with the formula of the myth of 'order out of chaos', and set out again with me on an examination of the problem in terms of circular and straight, or rectilinear, motion. Do you agree that the primordial or preceding and ungenerated motion would have to be circular, given the predicates we assigned to that kind of motion, that, especially, it departs from and returns to the same place in one continuous motion, without having to stop upon its return, and may continue over through the same course along a circumference again and again in a single continual motion ad infinitum?

Galileo: I admit that point.

Simplicius of Cilicia: And do you also agree that the kind of motion that was generated would have to be rectilinear, as all motions with a beginning and end that are to and from two different places are necessarily the product of generation.

Galileo: Yes, that much is clear.

Simplicius of Cilicia: Then, regardless of chaos and order, we are in agreement that the only kind of motion that can and must be ascribed to generation is rectilinear, and that the circular motion of the celestial bodies has to be ungenerated, without beginning, and the cause of generation, having been prior to all generation of rectilinear motion and as obviously more perfect and complete than them. Can't we?

Galileo: We can.

Simplicius of Cilicia: Or else, if the primordial motion that was prior to generation was rectilinear, we would be required to find an account of the cause of that in turn, since no rectilinear motion can be go on infinitely, but must start and stop at two different places, as limits terminating any one of its movements. Equally as absurd as not inquiring after a cause of a supposed rectilinear primordial motion is demanding a cause for the beginning of the circular motions of the celestial bodies, as they themselves, including their predicates, are sufficient to explain their origin and exhaust the search for their cause. Then, obviously there is something wrong and backwards with the myth about order generated out of chaos, especially if the heavenly spheres are said to be among the order which was generated—not only because they are complete, perfect, and sufficient as a cause unto themselves, but also because they couldn’t have as their cause something inferior to them.

Since we have reached agreement about the nature and predicates of bodies that have a natural principle of circular or of straight motion, something may be said about the ‘order out of chaos’ myth. If by ‘order’, the circularly moving celestial bodies are meant, then, as we said, an absurdity will follow, namely, that they, who are themselves a sufficient explanation of their own cause, will be said to be produced from something inferior to themselves, and that, I mean rectilinear motion, will be insufficient to be its own explanation of its own cause. Then if, by ‘order’ is meant rectilinear motion and the bodies that carries around, ‘chaos’ will then mean circular motion, which although not subject to generation, will be dishonored by the quality assigned to them as ‘disordered’ relative to rectilinear motion and the objects that move thus. In which case it becomes obvious that there is at the root of the problem a divergence of views regarding the axiom that I mentioned earlier, that the inferior cannot be the cause of the superior.

At the very minimum, then, the celestial bodies and their circular motions must be ungenerated and not subject to the story of order being created out of chaos, since that myth would predicate the quality ‘chaotic’ of them, as we say they are primordial to generation and that was the supposed establishment of order. Also, and this is directed at you, Galileo, rectilinear motion has a place in the scope of nature, since straight motion requires an account of its beginning or origin, and generation can only refer to objects with rectilinear motion and affectations, combined with the fact that we accept generation as a given. Recall, also, that this inquiry began with the aim of discovering a foundation with which to affirm a natural principle of rectilinear motion— after you had said there was no principle of rectilinear motion in nature once order was generated. And observe how what I argued for before has come true—that generation is bound up with rectilinear motion. So, by your own major premise, the acclaimed perfect order of the world, look what has followed. Not even that premise of order out of chaos remains after my most recent attack, but all has been overturned.

Galileo: That is all good and well according to the argument. However, if, going back to the beginning of our discussion, I deny the premise that earth and fire each have rectilinear motion opposite to each other, as I indeed wish, then the conclusions you have drawn will no longer follow.[58] For my own position is that there is no rectilinear motion in nature, and neither would you be able to prove that there is, if I withdraw my admission that heavy bodies move towards the center in straight lines and light bodies move naturally upwards towards the circumference. My position from there would take away all your leverage in the argument up till now. Then, perhaps, I could maintain

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[58] *Galileo. Dialogue Concerning the Two Chief World Systems*. Pg. 37, 39

the position I hold that there is no principle of straight motion, strictly speaking.
Simplicius of Cilicia: And how could you possibly deny that earth and fire move rectilinearly in contrary directions? I think you are making comments like that in jest, and don't seriously hold that opinion.
Galileo: As you will see, they are in accordance with my statement denying rectilinear motion in a perfectly ordered world.
Simplicius of Cilicia: Well, since our previous argument has reached its end, and we have yet to hear your illustration of the Copernican cosmology, I will contend with you about that as well.

Galileo: In accordance with the position I have argued for, I will begin from the same premise about the perfect order of the cosmos, upon which rests the claim that there can be no principle of rectilinear motion in nature. The most that can be said about motion along straight lines in nature, and which I can compromise the admission of, is that after parts of any of the elemental bodies are separated from their general mass of kindred species, they return to their natural place in a straight line.[59] However, I am more readily inclined to deny the claim that parts that have been separated by force from their natural place of union with their kindred species return with rectilinear movement. I claim that elemental parts return to their natural place by way of either circular or mixed movement.[60] Then, in either case, you will find that the elemental bodies don't have as a primary principle of motion rectilinear movement.[61] For, in the case of the compromise I was hesitatingly willing to make, that parts separated from their kindred species and natural place by force return rectilinearly, you will find that such a principle of motion can only be considered as belonging to them secondarily, and that once they have returned to their own natural place of belonging, they, along with the conglomerate mass of their kindred species, no longer move rectilinearly, that being the mode of their returning after their displacement and separation from their natural place.[62] And consider, if rectilinear motion belonged to separated parts and the whole of the Earth alike, then upon the return of heavy bodies to their kindred, the whole would naturally move rectilinearly somewhere or other. But, neither of us think the Earth as a whole moves in a straight line, which it would if it had as a principle rectilinear motion. The only possible way to account for this problem is to say that the separated parts aren't driven by a motive principle unique to their species as such-and-such an element, but are propelled to return to the place they were separated from by a secondary principle of motion common, not as much to all elemental bodies, but to all elemental bodies that are separated from their own kindred mass. None, however, of any of the whole species of elemental bodies has such a rectilinear principle of motion, as none of them taken as a whole are by anyone thought to move in a straight line. Then in the second case, if as I said, parts separated off from their natural place and kindred species move with either circular or a mixture of circular and straight motions, and not rectilinearly,[63] neither will there be anything that moves rectilinearly. For, in that case, neither the return of separated parts nor the whole of any of those species will move rectilinearly. That being settled, there is a weightier conclusion to argue for. If, as the previous argument shows, there is no place for a principle of rectilinear motion amongst the elemental bodies in terms of any of their whole species, and the most that can be granted to rectilinear motion is in the return of separated parts back to their natural place, which must be a secondary principle of motion not primarily natural to any of the elemental bodies, we cannot distinguish celestial bodies from elemental bodies according to kinds of motion. And as the Aristotelian argument for the difference between celestial and elemental substances depends on distinguishing the kinds of motion between celestial and elemental bodies, there will no longer be a clear distinction between the substances of celestial and elemental bodies.[64] With that established, one of two results follow—either the predicates attributed to elemental bodies will be applicable to celestial bodies, such as generable, corruptible, and alterable, or the predicates attributed to the celestial bodies will be attributed to elemental bodies, such as ungenerable, incorruptible, and unalterable.[65] So, which do you choose, Simplicius? Would you say that the heavens are alterable and corruptible, or that the elemental bodies are ungenerable, incorruptible, and unalterable?

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[59] *Galileo. Dialogue Concerning the Two Chief World Systems*. Pg. 32

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[60] *Galileo. Dialogue Concerning the Two Chief World Systems*. Pg. 33

[61] *Galileo. Dialogue Concerning the Two Chief World Systems*. Pg. 19, 32, 33, 45, 46

[62] *Galileo. Dialogue Concerning the Two Chief World Systems*. Pg. 45, 46

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[63] *Galileo. Dialogue Concerning the Two Chief World Systems*. Pg. 33

Simplicius: Stop there at let me address each of the propositions separately, and we will eventually get to your final conclusion. The only thing I admit is that you have illustrated the Copernican cosmology, which to hear about was our second objective after our primary objective of disproving it. I will go through your argument one step at a time, so I know I have your agreement and haven't lost you along the way.
Galileo: I am curious as to how you could resolve them.
Simplicius of Cilicia: Then answer when I ask if you approve.
Galileo: I will.

Simplicius of Cilicia: As to the first part of your argument, that the only use of rectilinear motion in nature is to restore the parts of elemental bodies that have been forcibly separated from their natural place and kindred species, I don't have an immediate problem with. That what our Peripatetic school has been arguing for centuries upon centuries,[66] which is perhaps why you falter on granting your full admission. We qualify the statement, however with the addition that the natural rectilinear motion is 'towards their natural place of rest'— [as rectilinear motion must have some end point, where it ceases to move and rests]. As to your statement that such a restorative motive principle must be secondary to such-and-such an element, we are not far off from that perspective either. For, we admittedly say that separated parts are restored to their natural place in rectilinear motion by a principle of movement that has them cease from motion upon their arrival, and that no such principle of motion applies to their kindred mass at their natural place. There is no need to argue about whether or not the whole Earth moves rectilinearly. Since we consider the Earth taken as a whole as stationary, we should naturally avoid terming their rectilinear and restorative motion as 'secondary'. I find it to be a merely nominative problem to dispute over whether rectilinear restorative motion is common to all elements, since of course they have that aspect of motion in common, yet there is a distinction between the directions they move towards, which does make their rectilinear motion qualified by the natural direction they have seem to be unique to them, whereas you say the restorative rectilinear motion of elemental parts is simply common to them alike.

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[64] *Galileo. Dialogue Concerning the Two Chief World Systems*. Pg. 37, 46

[65] *Galileo. Dialogue Concerning the Two Chief World Systems*. Pg. 37, 39

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[66] *Aristotle. Physica.* VIII. 4. 255a, 1-5, 255b, 13-17

… As to the second option you offer, that parts separated from their whole and from their place of rest don’t return rectilinearly but with either circular or mixed movement,[67] I am entirely at odds with and contentious about. Tell me, are the parts of earth, as elements, simple bodies?[68]
Galileo: Yes
Simplicius of Cilicia: And don’t simple bodies move with simple motions,[69] or would you contend with that point?
Galileo: Suppose I agree, then what?
Simplicius of Cilicia: Then, the parts of earth couldn’t return to the whole Earth by a mixed motion, could they?
Galileo: I suppose not.
Simplicius of Cilicia: And are not the only kinds of simple motion circular and rectilinear?
Galileo: I reply in accordance with your statement.
Simplicius of Cilicia: And do heavy and light bodies move contrarily?
Galileo: Yes
Simplicius of Cilicia: Meaning to and from opposite ends of a line?
Galileo: I agree.

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[67] *Galileo. Dialogue Concerning the Two Chief World Systems*. Pg. 33

[68] *Aristotle. De Caelo*. I. 2. 268b, 27-30

[69] *Aristotle. De Caelo*. I. 2. 269a, 3-4; I. 3. 270b, 27-28

Simplicius of Cilicia: And weight tends downwards, or towards the center, while lightness tends upwards, or towards the circumference?
Galileo: Yes, with the qualification that we don’t know or agree about the whereabouts of the center and circumference—whether they correspond with the center and circumference of the cosmos or not.
Simplicius of Cilicia: That isn’t as yet relevant. Tell me this. Is the only line that has as its contraries the center and the circumference of a circle a straight line?
Galileo: Yes
Simplicius of Cilicia: Then is it not clear that parts separated from their whole return with rectilinear motion?
Galileo: According to the argument.
Simplicius of Cilicia: Well, if you doubt the argument, just consider if parts separated and moving back to their natural place would take a direct or indirect route?
Galileo: A direct route
Simplicius of Cilicia: And the shortest, fastest, and most direct path across the interval between two points is along a straight line?
Galileo: Yes
Simplicius of Cilicia: Then parts separated from their kindred species will return along a straight path. And once again, the same result follows.
Galileo: I see

Simplicius of Cilicia: And tell me, if the distinction holds between the species of motion of elemental and celestial bodies, won’t you be unable to jest about their having the same substance, and being indifferentiable in that respect? And let me tell you, I hold you in

contempt for the impious nature of your argument, and I suppose you adopted the arguments of John Philoponus to your own purpose, for I haven't heard a single argument of yours that doesn't end in a conclusion which he also attempted to prove. We have now to further examine if the celestial and elemental bodies have different substances, as that problem deserves more consideration, and as our disagreement, I suppose, reaches its extreme therein. For therein lays our conviction that the heavens are aeternal and ungenerated. Will you continue the discussion regarding that topic?
Galileo: I will continue the discussion about that with you.

Simplicius of Cilicia: Although so much had already been said about this, there is much more still to say, and I doubt we could exhaust the topic or grow weary of the pleasure of such a discussion. There are other avenues from which to approach the subject. Let us turn the discussion in the direction of an inquiry into motion in general. The answer to the following question will grant us leverage in our inquiry into the generability or ingenerability of the heavens. Was there a beginning to motion, before which there was no movement? Or is motion ungenerated and aeternal?[70]

Galileo: How do you suggest we should confront that question?

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[70] *Aristotle. Physica.* VIII. 1. 250b, 10-14

Simplicius of Cilicia: First we must agree about the definition of terms. Do you accept our definition of motion, when we say that motion is the actuality of the moveable in so far as it is moveable.[71]
Galileo: I don't find disagreement with your definition, but I would like you to explain what you mean.
Simplicius of Cilicia: I mean this—each kind of motion necessarily involves the presence of the things that are capable of motion. Or, in other words, something has a potentiality for some motion before they are set into that specific motion, which we say, in general terms, is simply the actualization of that potential or capability of theirs. This applies to local motion and alteration alike. Thus, it is that which is capable of alteration that is altered, and that which is capable of local change that is in locomotion; and so there must be something capable of being burned before there can be a process of being burned, and something capable of burning before there can be a process of burning. Two things must have the active and passive potentiality, respectively, beforehand, in order for the given process of affection to occur.[72] Do you accept this characterization of motion as the actuality of a potentiality or capability?
Galileo: Yes

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[71] *Aristotle. Physica.* VIII. 1. 251a, 9-11

[72] *Aristotle. Physica.* VIII. 1. 251a, 12-16

Simplicius: These things also must either have a beginning before which they had no being, or they must be eternal.[73]
Galileo: Of course
Simplicius: Then that is the question under investigation. First, however—is it clear to you that all things that are capable of affecting and being affected, or of causing motion and being moved, are capable of it not under all conditions, but only when they are in a particular condition and approach one another—so it is on the approach of one thing to another that the one causes motion and the other is moved, and when they are present under such conditions as to render the one motive and the other movable?[74]
Galileo: Yes, that is clear.
Simplicius: Then if there was not always motion, they could not have been in a condition such as to render them capable respectively of being moved and of causing motion, but one or the other of them needed first to move or change.[75] For, the capability of one of them to affect the other and the other's capability to be affected, if that were the first motion, would never occur without a prior motion of them being brought together within proximity. Is that something you accept?
Galileo: I am led to agree.

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[73] *Aristotle. Physica.* VIII. 1. 251a, 17-18

[74] *Aristotle. Physica.* VIII. 1. 251b, 1-5

[75] *Aristotle. Physica.* VIII. 1. 251b, 5-8

Simplicius: It follows then, that there will be a change previous to the first.[76] And, supposing that there was a becoming of every movable thing, it follows that before the motion in question another change or motion must have taken place in which that which is capable of being moved or of causing motion became thus capable.[77]

Galileo: I follow the argument.

Simplicius: This equally applies to the demiurge and generation as well as to the first mover, for, any motion or affectation requires two things, one motive in capability and the other capable of being moved—one actively and one passively capable of the same affection or motion—and there is no reason why the first motion, affectation, or generation would have occurred at one time rather than another, if there was not some prior movement that brought them together such as to render the conditions with which their capabilities could be actualized. So, for any hypothesized 'first motion', there will always be another motion that is logically prior.[78]

Galileo: I can only say that I am stricken with wonder at the argument.

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[76] *Aristotle. Physica.* VIII. 1. 251b, 9-10

[77] *Aristotle. Physica.* VIII. 1. 251a, 18-21

[78] *Aristotle. Physica.* VIII. 1. 251a, 22-28

Simplicius of Cilicia: Our inquiry should now take a turn to the subject of time. First tell me if there can be any before and after without the existence of time?[79]
Galileo: There could never be before and after without time.
Simplicius of Cilicia: Could there be before and after without change and motion, or do time and motion mutually coincide, so that the only sense of the states of time—before and after—can be in reference to some change, motion, or alteration.[80]
Galileo: Without change or motion there would be no sense of the terms before and after. Time and change are bound up with each other.
Simplicius of Cilicia: But we said motion had no beginning?
Galileo: According to the previous argument
Simplicius of Cilicia: Then, if the states of time—before and after— refer to change and motion, and motion had no beginning, doesn't it follow that time also, as a whole, had no beginning?[81]
Galileo: That follows from the argument.

Simplicius of Cilicia: Here is a more convincing proof. Do you agree that the now, or the moment, is a kind of middle point connecting and dividing 'before and after', and is both a beginning and an end—the beginning of the future and the end of the past—like a point along a continuous line?[82]

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[79] *Aristotle. Physica.* VIII. 1. 251b, 11

[80] *Aristotle. Physica.* VIII. 1. 251b, 12

[81] *Aristotle. Physica.* VIII. 1. 251b, 14-15

Galileo: That is a fair description of the 'now', or the moment.

Simplicius of Cilicia: And before and after, past and future, are comprised of a continuous string of moments, or 'nows'? I mean to ask, if that isn't clear, if out of the three parts of time—before, now, and after—if time, while it is 'actual', is always 'now', and that when any point in time before 'was actual', it was similarly 'now', and once future times become actualized they will become 'now'; and after which, when they no longer are, or no longer 'are actual', and have passed, they cease to be 'now'. Is that plain enough for you?

Galileo: Yes, that is plain enough.

Simplicius of Cilicia: That having been said, suppose we hypothesize a beginning of time. We will inevitably find at the beginning of time, a moment, since at the time when the beginning of time was 'actually present', it was a 'now' and a 'moment', will we not?

Galileo: We will

Simplicius of Cilicia: But since 'now' is always suspended between before and after, as the end of the former and the beginning of the latter, for whatever 'now' we hypothesize as the beginning of time, we will necessarily find time on both sides of it, and there will always be 'before' that moment.[83]

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[82] *Aristotle. Physica.* VIII. 1. 251b, 20-22

[83] *Aristotle. Physica.* VIII. 1. 251b, 24-26

Galileo: That sounds right.
Simplicius of Cilicia: Then there must always be time, and time couldn't have possibly had a beginning, or have an end.
Galileo: That is a convincing argument.
Simplicius of Cilicia: And we agreed that where time was present, motion would also be present, since before and after are only applicable to changes and motion—as there has to be change for something to move through the states of being 'after the present', to actual, and from there to 'before the present'?
Galileo: We did
Simplicius of Cilicia: Then, if there is no beginning or end of time, and time is inseparable from motion, then neither does motion have a beginning or end, considered as a whole. And we reach the same result, once again. For a motion and time mutually coincide, such as to be inseparable, so that wherever one of them is present, so will the other be present, a proof of the aeternity of either of them will apply equally to the other, and vice-versa.
Galileo: And to me, the argument from time having no beginning is more convincing even of the claim that motion has no beginning.

Simplicius of Cilicia: We should now take up a different route, having settled the issue about motion and time. The subsequent inquiry that naturally follows is about 'place', space, or intervals of magnitude. This topic is more difficult and obscure, partly due to lack of knowledge handed down to us from our ancestors.[84] I mean by 'place' or space or

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[84] *Aristotle. Physica.* IV. 1. 208a, 33-35

intervals of magnitude neither geometrical intervals nor void, but physical space, and that not as a whole, but as ‘places’—to choose the most precise term—which are occupied by bodies. The topic, as I said, has been overlooked and neglected by most natural philosophers before us, or else alluded to by aenigmas.
Galileo: Go on.

Simplicius of Cilicia: To introduce the topic—there is the ancient formula stretching back to Zeno of Elea, who would say that if something is, it must be somewhere, and likewise, that nothing could be nowhere—[85] or, in other words—if upon inquiry of the whereabouts of something in question, the respondent answers that it is ‘nowhere’, then Zeno would say that the thing inquired about must not exist. He means, as well, that if, upon asking someone where the horses they are selling were raised and where they were brought from, and they replied that they were not raised or brought from anywhere, something would obviously be faulty about their response. We shall avoid attempting to resolve the dilemma he posed, however, we shall preserve and use that maneuver. For the sake of this argument, I only wish to highlight the importance of ‘place’ as a necessary predicate of ‘being’, and of ‘nowhere’ as a necessary predicate of ‘nothing’. Now, to get on with the inquiry at hand. You must agree that motion, in its most general and proper sense, is ‘change of place’.[86] Do you not?

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[85] *Aristotle. Physica.* IV. 1. 208a, 29-30

[86] *Aristotle. Physica.* IV. 1. 208a, 30-32

Galileo: I agree
Simplicius of Cilicia: Then, the obvious inference is that place is bound up with motion, much like we said about the inseparability of motion with time. Is that even remotely deniable?
Galileo: That inference is plain and obvious.
Simplicius of Cilicia: Then, if motion is without a beginning, without an end, and aeternal, and motion requires 'place' to transit and be carried to and from, then mustn't 'place' share the same attributes of motion, that is, having no beginning, no end, and persisting aeternally?
Galileo: Place must have those attributes, according to the argument.

Simplicius of Cilicia: And that is only right, upon further speculation. For, 'place' has, as much as anything, the property of preservation. For one, the existence of place as a separate entity is clearly discernable from the fact of mutual replacement. Where water once was, and has passed from, air is then present, and at another time another body occupies this same place. So, the place or space, into which and out of which they passed, is clearly different and separable from all the bodies which came to occupy and replace one another in it.[87] And while the mutually replacing bodies that occupy a place are admittedly more corruptible than the place they inhabited, unless the place happens to be a container or structure that decays *per accidens*, all of which makes for a telling remark toward the preservative nature of 'places' or spaces.

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[87] *Aristotle. Physica.* IV. 1. 208b, 1-8

Galileo: That does support the brief proof already made.
Simplicius of Cilicia: Yet the initial proof was enough for the purpose. For if motion and time are mutually connected and inseparable, and one of them was—really both were—shown to be beginningless, endless, and aeternal, then, reciprocally, the other must necessarily share those same predicates with its mutual dependent [term]. And if 'place' is the logical antecedent of 'motion' *ob analysis*, then 'place' must be logically prior to 'motion', and therefore qualified by those same attributes of beginningless, endless, and aeternal. Although the three terms, motion, time, and place aren't in the ratio of an equilateral triangle, since 'time' may not be directly mutually reciprocal with 'place', 'time' is mutually reciprocal with 'motion' in terms of the relevant attributes, and 'motion' is logically anteceded by 'place', so that they are proportionate to a right triangle in figure, so to speak.

I will share a further support of the primary proof to this part of the argument if you wish. Perhaps that would be helpful since 'place' is a more obscure term to comprehend in comparison to 'motion' and 'time'.
Galileo: Please

Simplicius of Cilicia: The locomotions of the elementary natural bodies—namely, earth, fire, and the like—show not only that place is something, but also that it exerts a certain influence. Each is carried to its own place, if not hindered, the one up, the other down. Upwards and downwards are natural distinctions of place, along with north, south, east, and west. The implication is that these places do not differ merely in position, but also as possessing distinct powers.[88] That goes to show that 'place' is an intrinsic part of the structure of the cosmos with influence over the elemental and celestial bodies.

Galileo: That seems to be an important addition to the argument.

Simplicius of Cilicia: And, although I contend with the argument, there is Hesiod's account that might or might not be useful regarding the prior problem, though in reference to our current topic, of the 'chaos out of order' myth. He says, "first of all things came chaos into being, then broad breasted earth,"[89] implying that things need to have space first, because he thought, with most people, that everything is somewhere in place. If this is its nature, the power of place must be a marvellous thing, and be prior to all other things. For that without which nothing else can exist, while it can exist without them, must needs be first; for place does not pass out of existence when the things in it are annihilated.[90] Regardless of my arguments in the discussion thus far, Hesiod's fables are up for interpretation, there is significance in his evaluation of what I interpret to be 'place' as primary in the generations of the gods. And notice that there is no evaluative term such as 'order' to diametrically oppose the chaos in an evaluatively negative sense.

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[88] *Aristotle. Physica.* IV. 1. 208b, 9-12, 21-22

[89] *Hesiod. Theogony. 116*

[90] *Aristotle. Physica.* IV. 1. 208b, 28- 209a, 2

Galileo: Hesiod's version of the myth has the concept of chaos in common with many other versions, however I understand there is a great deal about which they differ.
Simplicius of Cilicia: And much more that differs according to my interpretation, however, we need not get carried away with mythological fansy at this part of the discussion. Having reached agreement about place being logically antecedent to motion, we can safely rank place as, along with motion and time, characterized by the attributes of beginningless, endless, and aeternal.

We should turn to the following term to inquire about along the same lines as we have with motion, time, and place, that is, matter. Something might be said about the possible confusion between place and matter, as matter is somewhat easier to speak about, and place, due to obscurity, is sometimes spoken of as the same as matter. There is also almost the same method of identifying them and inferring that they each have a separate existence. Matter even seems to be place, if we consider it in what is at rest and is not separate but in continuity. For just as in change of quality there is something which was formerly black and is now white, or formerly soft and now hard—this is why we say that some underlying matter exists—so place, because it presents a similar phenomenon, is thought to exist—only in the one case we say so because *what* was air is now water, in the other because *where* air formerly was there is now water. But the matter is neither separable from the thing nor

contains it, whereas place has both characteristics.[91] Do you notice that both are identified by remaining through the changes of something else?
Galileo: Yes, the way they are identified is nearly the same.

Simplicius of Cilicia: Then let us begin the inquiry about matter. Are you familiar with this way of talking about matter—I say that there must be something underlying all change and becoming, for when something comes to be of such a quantity or quality or in such a relation, time, or place, a subject is always presupposed. Otherwise, what comes to be would do so from what is not, or from a privation, which is impossible.[92] We can go through the steps of the argument, nonetheless.

All change and alteration are to and from contraries, like hot and cold, moist and dry, more and less, front and back, hunger and satiety, and so on. Is that plain to you? Or could something become cold from being anything other than hot, and could anything become dry without becoming so from previously being moist, and could something become less from anything other than previously being more?
Galileo: That is plain and clear to me.
Simplicius of Cilicia: Well, consider, could heat itself become cold, or moisture itself become dry, or more itself become less, or hunger itself become satiated?

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[91] *Aristotle. Physica.* IV. 4. 211b, 30- 212a, 2

[92] *Aristotle. Physica.* I. 7. 190a, 33- 190b, 5

Or is it much better to say that heat departs at the onset of coldness, and some third thing underlying the quality becomes cold and ceases to be hot; and to say that moisture flees at the approach of dryness, and some underlying substratum that is capable of both moisture and dryness ceases to be moist and becomes dry; and that hunger doesn't itself become satiated, for then it would cease to be hunger, and would be something else, but that some third thing capable of both affectations ceases to be hunger at the approach of satiety. Do you see the problem with heat itself becoming cold? Then a contradiction would arise, and heat would be and not be heat, since we, by saying 'the heat became cold', would be simultaneously referring to one thing, heat, as its opposite, which is the absence of heat; but heat, of all things, is not and could not ever be cold or the absence of itself; for then heat would at once be and not be heat, and such a contradiction is impossible.[93]
Galileo: I follow the argument and agree that there must be something underlying change and alteration, as those occur to and from opposites, which are mutually the absence of each other and could never themselves become the other of them.

Simplicius of Cilicia: And do you accept that this underlying substratum is matter?
Galileo: Yes
Simplicius of Cilicia: And do you say with me that the underlying substratum or matter is that from which

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[93] *Plato. Phaedo*

things are generated and come to be, and without which generation wouldn't be possible?[94]

Galileo: Yes

Simplicius of Cilicia: Then if matter had a beginning and came to be at some time, something must have existed as a primary substratum from which it should be generated from and which should persist in it; but this is its own very nature, so that it will be before coming to be.[95] Is that not impossible, and must the substratum out of which things are generated be itself without generation, that is, if it really is the underlying substratum?

Galileo: The substratum that underlies generation couldn't have come to be.

Simplicius of Cilicia: Then matter didn't have a beginning in time, and therefore can't have an end in time, and is aeternal?

Galileo: That follows.

Simplicius of Cilicia: Then such is the case for motion, time, place, and matter. Now we will turn to the heavens once more and inquire into whether or not they meet the same criteria. There is more leverage and from a superior position after having already established that motion and time are aeternal.

Galileo: Go ahead with the argument.

Simplicius of Cilicia: If there must always be motion, as we have indeed established, there must be some

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[94] *Aristotle. Physica.* I. 7

[95] *Aristotle. Physica.* I. 9. 192a, 27-31

primary motion that is continuous and without break,[96] different from and alongside the various erratic finite movements, which would, without a single continuous movement alongside, characterize the infinite time we agreed motion to span to verge more on a confused disarray of the indefinite.
Galileo: What problems do you have in mind?

Simplicius: Well, all besides the primary kind of motion which we are seeking to find, all other motions are finite themselves. And although we agree that before any hypothesized 'first motion' there must have been another motion prior to that, or the capability of movable things would only be partial, and no actualization of their capability of moving and being moved would occur—even so, an infinite chain of finite motions without an overarching continuous motion to prevent interruption would be haphazard. We have proven that motion as a whole is aeternal, however, each specific motion is not infinite, and we ought to seek for a binding factor that is more than just accumulative addition. Answer this, and you will see the problem I mean to show—motion and change and alteration are for the most part from an opposite to and opposite, from a contrary to a contrary, is that right?[97]
Galileo: Yes, that is right.

Simplicius of Cilicia: And as to and from opposites, they require a 'double', so to speak, interchangeably

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[96] *Aristotle. Physica.* VIII. 7. 261a, 21-26

[97] *Aristotle. Physica.* VIII. 7. 261a, 33-38

successive to each other, so that whatever is under change must stop its motion upon approaching one opposite and turn back with a second motion towards the other, and then stop that motion before turning back again, and so on—[98] that goes for becoming and perishing, alteration of contrary affections, and for increase and decrease.
Galileo: We have spoken about that.
Simplicius of Cilicia: I don't doubt that such a mode of successive changes to and from opposites could be, and really is, aeternal, since upon the actualization of one opposite, the other becomes potential, and when that is actualized, the other is the only awaiting potential for the thing in question to become—and the potential can never be destroyed, and is, instead, inevitable upon the actualization of its contrary. Nonetheless, there should be something whose motion is without breaks and doesn't stop and turn around with two interchangeable opposite motions back and forth.
Galileo: That would grant a sort of completion to the accumulative finite motions, considered as a whole, that have been shown to always and forever be.

Simplicius of Cilicia: Now, we are looking for a motion that doesn't stop upon reaching one contrary and start a second motion towards the other contrary, then have to stop again before returning. Thus, we are looking for something with a continuous motion rather than broken successive motions between opposites, if

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[98] *Aristotle. Physica.* VIII. 7.

the whole of motion spanning infinite time is to be rounded off smoothly. Is that clear?
Galileo: I see your aim.
Simplicius of Cilicia: Now, locomotion is the only kind of change that can possibly meet this criterion. For, generation and destruction, alteration of affection, and increases and decrease all share the mode of having to turn back with a double motion between opposites, so that either of their single motions are relatively incomplete to what we are looking for.[99] Within locomotion, also, rectilinear movement on a finite line always has a beginning and end, for the line traversed in rectilinear motion cannot be infinite; for there is no such thing as an infinite straight line; and even if there were, it would not be traversed by anything in motion, for it is impossible to traverse an infinite distance. On the other hand, rectilinear motion on a finite line is composite if it turns back, having two motions, while if it does not turn back, it is incomplete and perishable.[100] The only remaining alternative to meet the criteria is circular motion. Circular motion, by going from a place to that same place will not be undergoing two contrary or opposite motions,[101] and subsequent repetition of the same course, going passed and around to that same place, grants it the characteristic of being continuous as a single motion without intermission and capable of a

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[99] *Aristotle. Physica.* VIII. 7. 261a, 29-38

[100] *Aristotle. Physica.* VIII. 9. 265a, 17-23

[101] *Aristotle. Physica.* VIII. 8. 264b, 10-14

multitude of cyclical rounds. In rectilinear motion there is beginning, middle, and end, and a state of rest at each limit. On the other hand, in circular motion there are no such definite points, for, why should any one point on the line be a limit rather than another? Any single point as much as any other may be regarded indifferently as beginning, middle, and end—the reason for this is that all these characteristics belong to the centre, as its locomotion is always proceeding about the centre and not to an extremity or limit. Beyond that, a circularly moving sphere is in a way both in motion and at rest—since the whole sphere occupies the same place, as both the center and the circumference remain in the same place as they were, while the parts of the sphere change position in relation to themselves.[102] Thus, the circular motion of a revolving sphere is the only kind of motion that admits of the continuity without break of a single motion with infinite repetitions, all the while, as a whole remaining in the same place unmoved. So, if motion considered as a whole has to be aeternal without interruption or break, and all other specific motions begin and end finitely in a state of rest, the circular revolutions of the heavenly spheres will be the only motions that meet the criteria of being capable of infinite duration, without beginning or end.
You have nothing to say, Galileo? I'll let you hold your peace, so to speak.

That should conclude our discussion about the difference in substance between the heavens and the elemental sphere beneath the moon. Such was only cursorily astronomical, and more inclined to philosophy per se, although the basis of our disagreement lays therein, I suppose.

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[102] *Aristotle. Physica.* VIII. 9. 265a, 29- 265b, 10

BOOK II.

Simplicius of Cilicia: Now we can advance to more exclusively astronomical content, which is what the masses find to be our fundamental disagreement. I suggest you lead this part of the discussion, Galileo, since it would be out of place for us to try to draw you in to the Aristotelian cosmology rather than let you lay out the general scheme of the theory of Copernicus. The framework of both cosmological systems should be illustrated for our listeners. The argument, I should say, hinges on the mobility or immobility of the earth, Copernicus and his followers adducing the movement of the earth, against the Aristotelians who adduce the contradictory position, of its immobility and stationary nature.

Galileo: Then I will begin by introducing the topic at hand. And let the inauguration of our reflections be the consideration that whatever motion comes to be attributed to the earth must necessarily remain imperceptible to us and as if nonexistence, so long as we look only at terrestrial objects; for as inhabitants of the earth, we consequently participate in the same motion.[103] But it is indeed just a necessary that it display itself very generally in all other visible bodies and objects which, being separated from the earth, do not take parts in this movement. So, the true method of investigating whether any motion can be attributed to the earth, and if so what it may be, is to observe whether bodies separated from the earth exhibit some appearance of motion which belongs equally to all. For a motion which is perceived only, for example, in the moon, and which does not affect Venus or Jupiter or the other stars, cannot in any way be the earth's or anything but the moons.

Now there is one motion which is most general and supreme over all, and it is that by which the sun, moon, and the five planets and fixed stars—in a word, the whole cosmos, the earth alone excepted—appear to be moved as a unit from east to west in the space of twenty-four hours, or a single day. This, insofar as appearances are concerned, may just as logically belong to the earth alone as to the rest of the cosmos, since the same appearances would prevail as much in the one situation as in the other.[104] Thus, it is that Aristotle and Ptolemy, who thoroughly understood this consideration, in their attempt to prove the earth immovable aim their arguments at a solution which accounts for this diurnal motion of risings and settings which carries the stars and luminaries around with its turning rotary movement. That may serve as our introduction to the topic.

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[103] *Galileo. Dialogue Concerning the Two Chief World Systems.* II. Pg. 114

Simplicius of Cilicia: That is a fair display of the phenomena that our theories contend to account for, that is, the diurnal motion. Now, before we contend about the motion or stability of the sun, and of the earth, I would like to draw a similarity. We seem to be in a quarrel that might be likened to that which the ancients told in fables as taking place between Atreus and Thyestes. Are you aware of that tale?

Galileo: I am not. Which do you mean?

Simplicius of Cilicia: I refer to an infamous quarrel between the brothers Atreus and Thyestes over the throne of Mycenae, filled with treachery, a woeful tragedy. Their household was cursed, you see, to be stained with strife and bloodshed. Thyestes by a deceptive plot obtained the throne from Atreus, who had agreed that whoever possessed the ram with golden fleece would be king, knowing that the ram was one amongst his own flock, not knowing, however, that his wife had betrayed him, and had given the golden ram to Thyestes, who then claimed the throne of Mycenae. Atreus retook the throne by a second wager, about which he persuaded Thyestes to agree that if the sun rose in the quarter where it then set, and set in the quarter where it then rose, then the royal scepter and throne should return to him. So it was that their kingdom rested on whether or not the sun would rise the next day over the horizon where it would usually then set. Whence, as the story is told, the sun changed directions, and took the course which is present nowadays, rising in the east and setting in the west, as a testimony in favor of Atreus. But before that quarrel between Atreus and Thyestes the sun previously rose and set in the other direction, until as Euripides tells, “Strife changed the course of the sun's winged chariot, fitting the westward path of the sky towards the single horse of Dawn; and Zeus diverted the career of the seven Pleiades into a new track and exchanged…”.[105] I bring this up, because our contention about whether the sun moves around the earth or the earth moves around the sun can be likened to this fable, as a reverse conception of the motion of the heavenly bodies and a reverse arrangement of the cosmos is the point of our contention, and we fancy ourselves to be contending for the throne of wisdom, which each of us can only secure by displacing the other’s theory.

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[104] *Galileo. Dialogue Concerning the Two Chief World Systems.* II. Pg. 114

Galileo: We do seem to be in a quarrel that can be likened to that myth.

Simplicius of Cilicia: And we might also be likened to quarrelling over a golden ram, if we interpret that as the sun, perhaps with the addition of reaching the equinox in Ares. However, that aside, we might each pray out in bewailing grief and lamentation for the toil with which we are required to bear, as Electra cried out in the lines immediately previous to the line from Euripides I quoted. "Oh! to reach that rock which hangs suspended midway between earth and heaven, that fragment from Olympus, which swings on chains of gold, so that I may utter my lament to Tantalus, my forefather, who begot the ancestors of my house,"[106] interpreting each of our ancestors as the forefathers of our theories.

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[105] *Euripides. Oresteia.* 1000-1005

Galileo: That also makes for a suitable commencement for this part of our discourse, alongside what I already said.

Simplicius of Cilicia: Yes, and we ought to return to the topic of our discussion before we let these fanciful poems sweep us away.

Galileo: Then let us resume the discussion. And what follows will be a set of problems set forth towards the improbability of the earth's immobility, and towards the probability of its mobile nature.

Now, having divided the cosmos into two parts, the earth and the heavens, one of which must be responsible for the apparent diurnal movement of risings and settings—one of which necessarily movable and the other motionless, it is the same thing to make the earth move alone, and to move all the rest of the cosmos, so far as any result which may depend on such movement. For the action of such a movement is only in relation between the celestial bodies and the earth, which relation alone is changed.[107] This is affect is commonly observed from aboard a ship at sea, from whose motion the coastline, which is necessarily motionless, is observed to move in the opposite direction as the sailboat really is moving. Now if precisely the same effect follows whether the earth is made to move and the rest of the cosmos stay still, or the earth alone remains fixed while the whole cosmos shares one motion, who is going to believe that nature (which by general agreement does not act by means of many things when it can do so by means of a few) has chosen to make an immense number of extremely large bodies move with inconceivable velocities, to achieve what could have been done by a moderate movement of one single body around its center?[108]

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[106] *Euripides. Oresteia.* 985

And, if we attribute the diurnal rotation to the highest heaven, then this has to made of such strength and power as to carry with it the innumerable host of fixed stars, all of them vast bodies and much larger than the earth, as well as to carry along the planetary orbs despite the fact that the two move naturally in opposite ways. Besides this, one must grant that the element of fire and the greater part of the air are likewise hurried along, and that only the smaller body of the earth remains defiant and resistant to such power. This seems to me most difficult; I do not understand why the earth, a suspended body balanced on its center and indifferent to motion or to rest, placed in and surrounded by an enclosing fluid, should not give in to such force and be carried around too. We encounter no such objections if we give the motion to the earth, a small and trifling body in comparison with the universe, and hence unable to do it any violence.[109] Now, for the sun to pass from one meridian to another, rise above this horizon and sink beneath that, causing now the day and now the night, and for the moon and the five planets and fixed stars to vary similarly—all these changes are in relation to the earth. All of them mean nothing except that the sun shows itself now over China, then to Persia, afterward to Egypt, to Greece, to France, Spain, and then America, etc. And the same holds for the moon and the rest of the heavenly bodies, this effect taking place in exactly the same way if, without disturbing any part of the universe, the terrestrial globe is made to revolve upon itself, rather than the starry skies made to move circularly around a stationary earth.[110]

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[107] *Galileo. Dialogue Concerning the Two Chief World Systems*. II. Pg. 116

[108] *Galileo. Dialogue Concerning the Two Chief World Systems*. II. Pg. 117

And here is a second difficulty for you, Simplicius. The probability of the motion of the earth and not the heavens being responsible for the apparent daily revolution of risings and settings is supported by the relative disruption of order that we surely see existing among those heavenly bodies whose circulation is not doubtful, but most certain. This order is such that the greater orbits complete their revolutions in longer times, and the lesser in shorter; thus Saturn, describing a greater cycle than the other planets, completes its cycle in thirty years; Jupiter revolves in its lesser cycle in twelve years; Mars in two years; Venus in three quarters of a year; and Mercury in [less time than that]; while the moon completes its cycle in a single month.[111] And this very harmonious trend will not be a bit altered if the earth is made to move on itself in twenty-four hours, or a single day. But if the earth is desired to remain motionless, it is necessary, after passing from the brief period of the moon to the other consecutively larger ones, and ultimately to that of Mars in two years, and the greater one of Jupiter in twelve, and from this to the still larger one of Saturn, whose period is thirty years—it is necessary, I say, to pass on beyond to another incomparably larger sphere, and make this one finish an entire revolution in twenty-four hours. Now this is the minimum disorder that can be introduced, for if one wished to pass from Saturn's sphere to the stellar, and make the latter so much greater than Saturn's that it would proportionately be suited to a very slow motion of many thousands of years, a much greater leap would be required to pass beyond that to a still larger one and then make that revolve in twenty-four hours. But by giving mobility to the earth, order becomes very well observed among the periods; from the very slow sphere of Saturn, one passes on to the entirely motionless fixed stars, and manages to escape the difficulty necessitated by supposing the stellar sphere to be moveable.[112]

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[109] *Galileo. Dialogue Concerning the Two Chief World Systems.* II. Pg. 120

[110] *Galileo. Dialogue Concerning the Two Chief World Systems.* II. Pg. 117

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[111] *Galileo. Dialogue Concerning the Two Chief World Systems*. II. Pg. 118

Then, and this is the third difficulty you must face, there is the difficulty of the immense disparity between motions of the stars, some of which would be moving very rapidly in vast cycles, and others slowly in smaller circles, according as they are located farther from or closer to the poles. This is indeed a nuisance, for just as we see that all those bodies whose motion is undoubted move in large circles, so it would not seem to have been good judgement to arrange bodies in such a way that they must move circularly at immense distances from the center, and then make [others] move in small circles. Thus, the size of the circles and consequently the velocities of motion of these stars would be very diverse from the orbits and motions of some others.[113]

Simplicius of Cilicia: As to your first point about the greater force needed to move the immense sphere of fixed stars, holding the thirty-six constellations, along with the luminaries, at a much greater velocity than would be needed to turn the earth, a body of lesser mass, around its own axis, I only need remind you that the motion in question isn't constrained, forced, or external to the body in question,[114] but natural to effortless, in the same way that it is effortless for fire to move upwards—and for whom a greater mass of fire means a greater upward velocity—due to the peculiar substance of the circularly revolving orbs. This is evident in the uniform and regular motion of the heavenly bodies, whose velocities and pace are always even, without either acceleration or retardation, without either slowing down or speeding up. Such would not be the case if the motion was forced upon them externally, which would rather result in a motion that begins more rapidly than it continues with and gradually becomes slower, in proportion to the exhausted effort of the mover.[115] But the outermost sphere that carries around the fixed stars and luminaries, rising in the east and sinking in the west, in a daily, twenty-four hour cycle, never moves irregularly, always keeping to a uniform and steady velocity, without acceleration or declination of pace. That tells us that the exertion of force is not constrained, but natural to that substance. Also, as the heavenly bodies, and above all the fixed stars, are primary and more complete than the earth and elemental bodies, they are more apt and better suited to be responsible for the apparent daily revolving of the luminaries and fixed stars.

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[112] *Galileo. Dialogue Concerning the Two Chief World Systems.* II. Pg. 119

[113] *Galileo. Dialogue Concerning the Two Chief World Systems.* II. Pg. 119

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[114] *Aristotle. De Caelo.* I. 2

[115] *Aristotle. De Caelo.* II. 6. 288a, 16-27

Then, as regards to the same problem, if the earth is to move—whether occupying the same place and revolving around its own center, or along a circumference and around a center different from its own, being removed from the center—it must be moved with such motion by restraint and external force, for this is not its natural motion. If circular motion was natural to it, all of its parts would move circularly also, but every one of them is moved along a straight line towards the centre.

Aristotle gives a cogent argument in accord with the previous argument which is also his. He asks, why then is not the whole body of the cosmos of the same character as the revolving heavens? Because there must be something at rest at the centre of the revolving body—we take this for granted as the apparent motion in question demands a changing relation between the positions of the luminaries and the earth—and of the revolving sphere of fixed stars, no part can be at rest, either elsewhere or at the centre.[116] This is evident in the consideration that the turning of a solid sphere of a single material has only a magnitude-less point unmoved at its centre, and we are inquiring after a centre that is not a magnitude-less point, but one with magnitude, the sphere of the earth, which would be carried along by and with the same circulation of the outermost sphere if not separate from them in substance and having a distinct natural motion. Again, there must be at least one other motion besides the circulation of the outermost sphere, since a single motion of the whole heaven would necessitate an identical relation of the elements of bodies to one another, indifferently. And earth is required because aeternal movement in one body necessitates aeternal rest in another.

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[116] *Aristotle. De Caelo.* II. 3. 286a, 11-16

Then also, if the sun were the body at rest at the center of the cosmos, we should expect to find that the parts of the sun moved towards the center. But if the sun is taken to be located at the centre, and the rays of light, which are the only noticeable parts of the sun, expand outward away from itself, then *eadem est ratio totius et partium*, the sun won't as a whole have a natural place of rest where the parts, in this case, rays of light, don't move towards on their own accord. That is to say that the sun shouldn't be thought of as placed at the centre of the cosmos. This is to say that the earth should be thought of a located at the centre. If something must be at rest, or at least have a separate motion different than that of the diurnal motion of risings and settings—to account for the relative change of the positions of luminaries among the fixed stars—and the parts of the earth move naturally towards the centre, at which point they rest—at least as parts—and a single simple body can only have one natural motion, then the earth rather than anything else must be at rest at the centre.

As to the second problem you posed, which you call a disharmonious arrangement in the progression from near to far of shorter to longer periods of time of each cycle—in other words, why the sphere of fixed stars, which is at an incomparable distance from us than the planets, with its diurnal motion revolves every twenty-four hours, while the planetary spheres revolve in an orderly progression, the nearer they are the faster they complete their cycle, and the further they are the slower they complete their cycle—I have the following resolution to state. The planetary and solar and lunar cycles obey their harmonious progression as you say, the nearer luminaries completing their cycles faster and the further planets completing their cycles more slowly, each contiguous with the next, moving from west to east. The cyclical motion of the fixed stars, although contiguous with the outermost planetary sphere, revolves east to west, in the direction reverse to the planetary, solar, and lunar movements. So, your suggestion that passing from the furthest planetary sphere to the sphere of the fixed stars breaches the harmonious progression that was found in passing from the innermost toward the outermost planetary cycles, ignores the difference in species of motion, or at least direction of motion between the two orders.

Each of the planets and the sun and moon move with their own separate motion, unaffected by and not affecting the other planetary motions they are contiguous with; again, from west to east. They are all, however, at the same time carried around in the opposite direction, from east to west, along with and by the sphere of fixed stars that rotates most rapidly with a twenty-four hour cycle, accounting for the rising and setting of all the luminaries. Thus, the planetary and solar and lunar spheres share in east to west motion that is imparted to them from the outermost sphere of constellations, while the latter is in no way affected by each separate and much slower planetary motion west to east. The diurnal twenty-four hour cycle is, then, common to all of the inner spheres, besides the earth, and you need not doubt the concordant role played by the outermost sphere, nor consider such an arrangement to be disharmonious. For, the harmonious cycles of the inner spheres span from twenty-eight days to twenty-eight or thirty years, and they require a faster cycle to carry them around the whole circle once a day.

For, if you object to this as mere fancying on my part, then I ask you, with what measure, if you take away the diurnal motion of risings and settings, could you use as the unit of measure for your harmonious progression? What I mean is this—the shortest cycle is that of the moon, spanning twenty-eight days, and if you take away the rising and setting that causes the division between and repetition of days and nights, for that is not the sun's own motion, you will have no unit of measure to compose the month. And without the month fixed to a certain number of days, if days are to be rendered meaningless, the month will be indeterminate, without discrete units of measure. Then, in turn, the annual or yearly cycle of the sun would suffer the same fate, without the discrete measure of days and a determinate month. You may respond that the sun's apparent rising and setting over the horizons can equally well be accounted for by the rotation of the earth about its centre, however that is not the question at hand, and it was already shown that the celestial bodies move with unrestrained motion natural to them that is orderly and invariant.

You pose a third problem that, if the outermost sphere of fixed stars is in motion, then there would result a great disparity and diversity of greater and lesser velocities and distances, with stars at vast distances from the centre moving at very rapid velocities and stars verging towards the poles moving at much slower velocities. You say that such an arrangement would be a ‘nuisance’ and ‘bad judgement’, presumably with your eye set towards keeping harmony free from inequality. That is, however, a natural property of spheres and of circular motion in general. For, when multiple circles are inscribed concentrically around the same centre, and revolved around their centre so as to complete each of their cycles in equal times, the circles with shorter radii, while completing their cycles in equal time with the circles with longer radii, cover a lesser distance. Now, there are two ways of defining the faster. The faster traverses an equal distance in a shorter amount of time, of course, but the faster also traverses in an equal time a longer distance. So, given the second definition of greater speed, circles with greater radii will, by traversing a longer distance in equal times, be faster. The stars located near the ecliptic must have a greater velocity in proportion to the greater distance they cover while inscribing their circuit in an equal time with the stars verging on the poles, which by covering a lesser distance in an equal amount of time must revolve at slower velocities.[117]

The perfection of the spherical, and of the circular, shape is, indeed, a wonder to contemplate, however that is not so much as the beginning of the awe that can be drawn from such speculation. You merely point out that there is an apparent inequality and think this to be a great disparity. You, perhaps, expect to find arithmetical equality, but much more beautiful is geometric or proportional equality, which is displayed in the characteristic of revolving spheres. For, in keeping to equal times in completing their circular motions, the sections of the sphere rotating around the axis—not the center of the sphere, about which they all have equal radii—maintain a speed proportionate to their distance from the center of their circle, so that the whole and each of the parts revolve around the axis in an equal amount of time. Since there are an infinite number of divisions that can be made along the axis of the earth, and further latitudinal lines can be drawn between any two points on that line, and given what was said, an equal amount of time for all circles along a sphere to complete their rotation around the axis as their common center is preserved amidst the infinite inequality of distances from the axis, by adapting each of their speeds proportionally to their distances—thus preserving the equal time of rotation.

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[117] *Aristotle. De Caelo.* II. 8. 289b, 34- 290a, 5

You might fall deeper into wonder when we reconsider the previous problem under this light. For what you thought was out of place and discordant—the rapid speed of the outermost sphere of constellations completion of its rotation in twenty-four hours—will turn out to be a wonder and spectacle of harmony and concord. You said that we should not expect the outermost sphere to move with such an inconceivable speed, when we find that the planetary orbits and those of the sun and moon are slower at greater distances and swifter at nearer distances. You figured that if the proportion is held in accordance with the inner spheres, the outermost sphere should revolve at a very slow rate of speed, as all the inner spheres are slower in proportion to their distance from the centre. I already argued that the outermost sphere revolves in the opposite direction from the planetary spheres and those of the sun and moon. You know, of course, that the planets and sun and moon share in the daily circuit of risings and settings by participation, and that their own separate motions are not east to west but west to east, at the slower rates of a month, a year, two years, twelve years, and twenty-eight or thirty years. You also know that the revolving outermost sphere that against our horizon provides for the risings and settings of all the heavenly bodies, carries them around uniformly so that they complete that daily cycle in times equal to their position according to lines of longitude.

That is only to set the problem conformable to the terms we were recently using regarding the proportionality of unequal distances and speeds to produce an equality of times of completed circuits. Consider this, then. Are not the relative speeds of the planets and sun and moon opposite to how we have been considering them amongst their own separate motions west to east? We said that as we passed from nearer to more distant spheres, we found that the speed and time it took them to complete their separate cycles decreased, from the moon with the swiftest cyclical completion to Saturn with the slowest cyclical completion. That, remember, is true regarding their west to east motion through the zodiac or ecliptic.

Well, as regards to their east to west motion in common with and by the way of the outermost sphere, from which they are observed to rise in the east and set in the west, we find that the nearer planets move slower, and the further planets move faster. This is in accord with the properties of a rotating sphere, and of those of the rotation of concentric circles, where the greater the distance from the centre, the greater the speed, given that the time for them all to revolve around the centre is equal. So, we find that the speed of Saturn, which has the slowest transit through the zodiac, is fastest among the planets, by way of covering a greater circumferential distance in equal time with all of the lower planets. And we find that the speed of the moon is slowest among the luminaries in the daily circuit from east to west, for the reason that the moon covers the least circumferential distance in the same amount of time in which the other planets cover a greater circumferential distance.

Is this not a spectacle of wonder—that in their own separate motions through the zodiac, the moon has the fastest cycle, of twenty-eight or thirty days, and Saturn has the slowest, of twenty-eight or thirty years; but in their common motion derived from the outermost sphere, from which they appear to rise over the eastern horizon and set over the western horizon, their relative and proportionate, I should add, speeds are the inverse, with the moon travelling the slowest and Saturn the fastest, in proportion to their distances from the centre, meanwhile revolving all the way around in the same and equal amount of time, twenty-four hours.

A reason for this may be provided that is given by Aristotle in response to the question why the outermost sphere, which carries around a great multitude of stars, has but one motion, that is, east to west, while the planetary spheres carry around a single luminary and have three motions—the daily east to west motion common to all, their separate transits through the zodiac west to east, and their periodic retrograde motions east to west; while the sun and moon have two motions, those of the planets excepting the reverse motion of periodic retrograde. He says that nature works like a balance and establishes equality, we might add—sometimes equality by arithmetical proportion, sometimes by geometrical proportion, and sometimes by harmonic proportion—giving to a single motion many bodies, and to a single body many motions. We might adapt the answer to our present ends, and say the same applies to the inversion of order of proportional speeds amongst the planets and sun and moon. Then, nature, like a balance, makes matters equal—adding more Tyrian dye to one end of the scale or more silver to the other end—and establishes a certain order; so that the swiftest east to west is Saturn and the slowest in that direction is the moon, and while the moon is swiftest west to east, and the slowest in that direction is Saturn—of the luminaries.

That, then, is my response to your problems posed against the theory of the earth's immobility. Now, I will, in turn, pose problems against your claim that the earth is in motion.

Notice this—you say that the theory of a moving earth and motionless heavenly spheres is capable of accounting for the same phenomena as does the theory of the motion of the heavens and the immobility of the earth.[118] According to you, both theories are able to explain the same apparent motion. From there, you rely on probability and improbability, never proving, or even arguing for, the impossibility of the earth's motionlessness, and never proving the necessity of the earth's motion. We, however, don't admit that any movement of the earth can account for the same celestial phenomena as the immobility of the earth along with the movement of the heavenly spheres. So, instead of relying on arguments from 'probability' and 'improbability', like some menial gambler, I will argue against even the 'possibility' of the mobility of the earth in accounting for the relevant celestial phenomena, and for the 'necessity' of the immobility of the earth and the 'necessary' movement of the heavenly spheres, if the relevant celestial phenomena can be accounted for at all. I won't rely on probability and improbability at all, and I will reduce the problem to terms of impossible or necessary.

I have presumably escaped the difficulties you set to me regarding the probability or improbability of the earth's immobility. You haven't, however, set forth a single argument that the motion of the heavenly spheres is impossible, or that the immobility of the earth is impossible, or that the motion of the earth is necessary, or that the immobility of the heavenly spheres is necessary. I, however, along with the philosopher, as some call him, or as we do, the 'daemonical Aristotle' wish to argue that the mobility of the earth is impossible, and that the immobility of the heavenly spheres is impossible, and that the immobility of the earth is necessary, and that the mobility of the heavens is necessary. I need but one argument to prove this. Yet, subsequent arguments will fall into place behind the marshalling first, in proportion to the divergence of views you possibly hold regarding the type of movement you ascribe to the earth.

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[118] *Galileo. Dialogue Concerning the Two Chief World Systems*. II. Pg. 114, 116, 117

As the daemonical Aristotle wrote in his lecture notes— "Everything that moves with the circular movement, except the first sphere, is observed to be passed, and to move with more than one motion. The earth, then, also, whether it moves along a circumference around the centre, or, set at the centre, revolves around its own center, must necessarily move with two motions. But if this were so, there would have to be passings and turnings of the fixed stars. Yet no such thing is observed. The same stars always rise and set in the same parts of the earth."[119]

Regarding this quotation, you know that he wants to reject two positions, as you agree and mention in your *Dialogue Concerning the Two Chief World Systems*— that of those who, placing the earth at the centre, make it move upon itself about its own centre, while the

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[119] *Aristotle. De Caelo.* II. 14, 296b, 33- 296b, 6

other belongs to those who, placing the earth distant from the centre, would make it move through a circumference circularly around the centre. Both of these positions he jointly opposes with the same argument.[120] Don't you have the characters in your dialogue mention that verbatim?
Galileo: Yes, those are the views that Aristotle opposes in the relevant passage.

Simplicius of Cilicia: Let us consider the first position, which places the earth at the centre and has it rotate around its own centre. Again he says, as you quote, "All the circularly moving bodies seem to lag behind and to move with more motions that one, except the sphere of the fixed stars (that is, the *primum mobile*); therefore, the earth, moving around its own centre and being placed at the centre, must be moved with two motions and must fall behind; but if this were the case, the risings and settings of the fixed stars would have to vary, which is not seen to happen; therefore the earth is not moved."[121]

Since this argument needs to be unraveled, I will pose the questions to you in a simpler manner, about which, if you don't answer in the appropriate manner, I will answer for you.

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[120] *Galileo. Dialogue Concerning the Two Chief World Systems*. II. Pg. 137

[121] *Galileo. Dialogue Concerning the Two Chief World Systems*. II. Pg. 137

So, to begin—If the cause of the apparent risings and settings over the horizons of the luminaries and fixed stars is not caused by any revolving of the heavenly spheres, but the turning of the earth about its centre, then the positions of the sun and moon and planets would not vary in relation to the zodiac of the fixed stars, but would likewise be fixed to the rest of the constellations. Is that right?
Galileo: Yes
Simplicius of Cilicia: However, they do vary in relation to the fixed stars, as they each transit the zodiacal belt by their own separate motions completed in different amounts of time. Then since the sun, and moon, and planets each change their position as regards to the fixed stars and the zodiac signs, and those motions and their change of position differ from the diurnal motion that we have hypothesized as caused by the motion of the earth, instead of by the outermost sphere of fixed stars, their motions can't be attributed to the rotation of the earth. Do you agree?
Galileo: I agree

Simplicius of Cilicia: You must agree, for you said that— "But on the other hand it is indeed just as necessary that the motion in question display itself very generally in all other visible bodies and objects which, being separated from the earth, do not take part in this movement. So, the true method of investigating whether any motion can be attributed to the earth, and if so, what it may be, is to observe and consider whether bodies separated from the earth exhibit some appearance of motion which belongs equally to all. For a motion which is perceived only, for example, in the moon, and which does not affect Venus or Jupiter or the other stars, cannot in any way be the earth's or anything but the moons."[122]

Then, since the motions of the sun and moon and planets through the zodiacal signs cannot be accounted for by the motion of the earth, or, for that matter, the daily risings and settings carried around by the fixed stars, the earth must be moved with two motions, as Aristotle makes a point to say. He adduces that from the observation that everything that moves with circular movement, except the first sphere, is observed to be passed, and to move with more than one motion. By 'passings' he means that the other circularly moving bodies, pass each other through the same zodiacal course, and that they also move with a variety of motions, sometimes turning back in retrograde and sometimes continuing forward. That is all to prove that there are necessarily two motions, at least, that the earth would be subject to, if it is to account for the apparent movements of the celestial bodies.

Galileo: I follow so far.
Simplicius of Cilicia: The argument doesn't stop there. However, you say that the people that hold that opinion about the earth rotating around its own centre in order to account for the apparent motion of the heavenly bodies, that,
"they don't attribute to the earth any motion but that one by which all the stars appear to be moving from east to west."[123]

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[122] *Galileo. Dialogue Concerning the Two Chief World Systems*. II. Pg. 114

This is unmistakably your claim, which I reference, since you said elsewhere—
"Make the earth the *primum mobile;* that is, make it revolve upon itself in twenty-four hours in the same way as all the other spheres. Then, without its imparting such a motion to any other planet or star, all of them will have their risings, settings, and in a word all their other appearances."[124]

We, however, will continue, after having established that the position they hold requires the earth to move with more than one motion. There is, then, the motion of separate luminaries in relation to, and through the course of, the fixed stars that is not attributable to the hypothesized single rotation of the earth, as those are also not attributable to the daily cyclical rotation of the fixed stars, which is what the hypothesized rotation of the earth about its centre is meant to account for. Is that much clear to you?
Galileo: Yes
Simplicius of Cilicia: Then we can relinquish the arguments you set against the theory of a stationary earth by reducing the many movements of the heavenly spheres to a single rotary motion of the earth around itself while positioned at the centre of the cosmos. To continue, then, with the argument—answer this—if a second motion is to be attributed to

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[123] *Galileo. Dialogue Concerning the Two Chief World Systems.* II. Pg. 138

[124] *Galileo. Dialogue Concerning the Two Chief World Systems.* II. Pg. 122

the earth, besides that which is hypothesized to account for the daily risings and settings, and this second motion of the earth is supposed to account for the motion of the planets and sun and moon through the zodiacal constellations, mustn't the earth be thought to move in the opposite direction from the first motion hypothesized?
Galileo: You mean to account for the west to east motion of the planets, sun, and moon?
Simplicius: Yes. As you say that the apparent east to west rising and setting motion of the heavens is accounted for by the hypothesized movement of the earth from west to east, wouldn't you require the earth to move in its second motion from east to west, in order to account for the motion of the planets from west to east?

Galileo: I suppose so, although I am not in a position to defend the theory, as I primary have intended to defend the heliocentric model of Copernicus, not the geocentric model that has the earth turn about its centre.
Simplicius of Cilicia: Then I don't know who will. Still, you must answer, or I will answer for you.
Galileo: Okay
Simplicius of Cilicia: Then, could the earth move from west to east and from east to west at the same time, or would that hypothesis rather require that the earth would have to pause its motion from west to east—which accounts for the daily rising and settings—to advance in the opposite direction east to west, to account for the planetary motions through the zodiac?

Galileo: If that is the meaning of this theory, then the two motions couldn't occur simultaneously, but would have to be consecutive interchangeably.

Simplicius of Cilicia: Then, tell me, upon the earth changing its motion from eastward to westward, wouldn't the stars that had risen just over the eastern horizon sink back down over the same horizon, and wouldn't the stars that most recently set over the western horizon rise back up over that same horizon, at the onset of the consecutive motion?

Galileo: That would make sense.

Simplicius of Cilicia: But, as the daemonical Aristotle says, there is no variation observed amongst the risings and settings of the fixed stars, and they have but one continuous, uninterrupted motion, unlike the diverse motions of each planet.

Galileo: Then such could not be the case.

Simplicius of Cilicia: Well, then set aside that interpretation of the 'second motion' of the earth required to account for the planetary motions west to east. I know not what other directional motion of the earth would feign to account for the planetary motions in the opposite direction of the risings and settings of the daily revolving cycle of the fixed stars. However, there would, beyond that, be required a third motion of the earth to account for the slight variation north and south of the sun and each of the other luminaries in their path through the zodiacal belt—as the path of the ecliptic runs oblique to the equatorial latitude. Then the earth would have to revolve slightly north and south, would it not?

Galileo: I suppose so.

Simplicius of Cilicia: Well, any revolving of the earth north or south would result in a shift in the equatorial

latitude in relation to the celestial equator, would it not? And the latitudes of the earth would discontinue to be aligned with the coordinates of the celestial latitudes, wouldn't they? And, perhaps Aristotle means this when he says that "there would have to be passings and turnings of the fixed stars, yet no such thing is observed. The same stars always rise and set in the same parts of the earth," that is, at the same lines of latitude.
Galileo: Yes, that would be the result.

Simplicius of Cilicia: Then the conclusion is that—if for the motion of the earth to account for the diverse motions of celestial bodies, one westward completing its cycle in twenty-four hours and many eastward completing their cycles in a diverse range of much slower times, the earth would have to move with more than one motion; and that any additional motion of the earth on top of the first hypothesized that was meant to account for the daily risings and settings, would disrupt the continuity between the points of latitude and cause stars to rise and set at different latitudinal degrees, but the same stars rise and set in the same parts of the earth—then, the conclusion is that, the motion of the earth cannot possibly account for the apparent and diverse motions of heavenly bodies. So, the hypothesis of the earth revolving around its own centre at the centre of the cosmos results in impossibilities and must be abandoned.
Galileo: Yes, according to the argument. I, however, don't hold that view.

Simplicius: Nonetheless, that position is half of the opposition against the contradictory hypothesis that we hold, that the earth is stationary and unmoving. For now, we have settled what I consider to be half of the problem—whether or not the earth, if positioned at the centre of the cosmos, is motionless or revolves around its own centre—the result being that the earth, if positioned at the centre of the cosmos, must not only be stationary, but then also, of course, the apparent motion of the heavenly bodies must be due to the heavenly bodies themselves. Now we can proceed to the second half of the problem, which can be put thus—whether or not the sun moves around the earth, or the earth moves around the sun. For that will be enough, for our part, if we sufficiently prove that the earth doesn't move around the sun after proving that the earth doesn't rotate around its own centre at the centre of the cosmos; the result being that the earth must be motionless and that the sun and other celestial bodies move in circles around it.

So, tell me, Galileo, is the earth's axis fixed to the northern celestial pole, as regards the annual cycle in question, or not?
Galileo: I say that the axis of the earth is fixed to the northern celestial pole, at least as can be noticed during the course of a great multitude of annual cycles.
Simplicius of Cilicia: And the fixed stars rise and set at the same latitudes north and south invariably?
Galileo: That is also true.
Simplicius of Cilicia: And do you agree that the sun's apparent position along its eastward course through the ecliptic has the slight variation of about twenty three degrees of latitude north of the celestial equator and the same degree of divergence south of the equatorial

line, accounting for the change of seasons on the earth?

Galileo: Yes, that is correct.

Simplicius of Cilicia: Now, either the motion of the earth or the motion of the sun must be responsible for the apparent variation of the position of the sun along with the corresponding change of seasons. Do you agree? And is that not the immediate problem at hand?

Galileo: Yes, inevitably the motion of the earth or the sun must be responsible for the apparent variation in position of the sun, both its divergence north and south and its apparent course through the zodiacal signs.

Simplicius of Cilicia: But, there is no variation northward or southward between the earth and the fixed stars, for the stars at certain celestial latitudes always rise and set at the same terrestrial latitudes invariably, right?

Galileo: That is right.

Simplicius of Cilicia: Then the earth's axis doesn't tilt in divergence from the northern celestial pole, not throughout the course of the annual solar cycle, but remains aligned to the celestial poles.

Galileo: I suppose you're right.

Simplicius of Cilicia: Yet the sun rises and sets at different latitudes variously throughout the course of a year, straying south of the equatorial line in the winter months, and north of the equatorial line in the summer months. Do you agree?

Galileo: Yes

Simplicius of Cilicia: Then, if the axis of the earth doesn't tilt or diverge in any way from the celestial poles, but the position of the sun changes in variation north and south in relation to both the celestial and

terrestrial latitudes, verging past the equatorial line towards the northern celestial pole in the summer and towards the southern celestial pole in the winter, then the sun must be responsible for its variation of position in relation to both the latitudinal lines of the earth and the latitudinal lines of the heavens alike.
Galileo: Perhaps
Simplicius of Cilicia: Perhaps? We agreed that the earth doesn't tilt from alignment with the celestial poles.
Galileo: What if I consider the celestial poles as relative to the spin of the earth, and not the natural axis of the cosmos?
Simplicius of Cilicia: Then I will simplify the argument for you. I neither think you believe that, nor that you pose a legitimate obstacle for the argument.

There are three variables to consider the relationships between: the celestial latitudes along with the rising and setting of their corresponding stars; the terrestrial latitudes; and the sun's position along celestial latitudes.

I say that, if the sun's apparent varying position relative to the earth along celestial latitudes has to be attributed to either the motion of the earth or the sun, but the relationship between celestial and terrestrial latitudes is constant, and the earth couldn't tilt or move north or south without disrupting the invariant relationship between the celestial and terrestrial latitudes, then the earth has no northern or southern motion in relation to the fixed stars, and therefore, anything else, and the variant position of the sun northward and southward of the equatorial line cannot be attributed to the tilting or any other motion of the earth, which has its axis fixed to the celestial poles.

Or again—as the angular position of the sun along lines of latitude is variant, but the earth can't move or tilt northward or southward, since celestial and terrestrial latitudes are constant, then the motion of the sun must be responsible for its variation north and south across lines of latitude, and for the angular difference that accounts for seasonal change.

And yet again, if you wish—If the earth moves in orbit around the sun, which is at the center, through the ecliptic or the zodiac signs, how is the latitude of each fixed star's rising and setting invariant? If the axis of the earth's 'tilt' is invariably fixed to the celestial poles, and the ecliptic is itself slanted twenty-three degrees and spans a great distance, then the earth would have to orbit like a wobbling top in order to keep the tilt of its axis fixed to the celestial poles. The only way to account for the seasons would be the earth's axis tilting to the north and south, or the earth's orbit straying north or south—to account for the sun's position south of the equator during the winter and north of the equator during the summer—yet, how then are the celestial poles and latitudinal lines invariant? For, any tilting of the earth north or south, to account for the angular position of the sun producing summer and winter seasons, would have to result in a proportional variation in the latitudinal position of the fixed stars and celestial poles. And if the earth tilted inward along its course through the ecliptic, to keep its axis fixed to the celestial poles, the northern hemisphere would always experience summer, for one, and also, there would be great variations across latitudinal lines of stars near the ecliptic and celestial equator.

You answer not? I will give you time by reviewing the problem. At least answer this—according to the heliocentric model presented by Copernicus, which has the earth moving around the sun, isn't the sun considered as motionless?
Galileo: Yes
Simplicius of Cilicia: And by that conception aren't the fixed stars considered as motionless, also?
Galileo: Yes, the fixed stars are also considered as motionless in the Copernican system.
Simplicius of Cilicia: Then, won't any and all apparent motions of the sun have to be attributed to the motion of the earth?
Galileo: That is the case.
Simplicius of Cilicia: And won't any and all apparent motions of the fixed stars have to be attributed to the motion of the earth as well?
Galileo: Yes, that also.
Simplicius of Cilicia: And doesn't the apparent annual motion of the sun west to east through the zodiacal belt include a slight variation north and south of the equatorial line?
Galileo: It does.
Simplicius of Cilicia: Then, if we attribute to the motion of the earth, the apparent motion of the sun including its variation north and south of the equatorial line, wouldn't that, since the fixed stars are hypothesized as motionless, also result in an apparent variation north and south of the fixed stars across lines of latitude, relative to and in proportion with the

apparent variation of the sun through its annual course, or the earth's actual motion that results in such phenomena?
Galileo: I suppose so.
Simplicius of Cilicia: But the fixed stars always rise and set over the same latitudinal lines of the earth? And the north star at the tail of Ursa Minor remains unmoved?
Galileo: Yes
Simplicius of Cilicia: Then, according to the argument, we cannot attribute the apparent motion of the sun, or its variation north and south of the equator, to the motion of the earth. Or else, we would see the same variation north and south across latitudinal lines of the fixed stars, and the northern celestial pole would shift from the tail of Ursa Minor by the same twenty three degrees in both directions over the course of a year.
Galileo: I follow the argument.

Simplicius of Cilicia: That is, since the sun and the fixed stars are hypothesized as stationary and motionless, any movement of the earth north and south would necessarily result in the apparent motion of both, which would be seen to vary in relation to latitudinal lines, and the resulting apparent motion of both the sun and the fixed stars would have to hold an invariant ratio. It is, then, impossible for there to be an apparent motion of the sun northward and southward without an accompanying apparent motion observed amongst the fixed stars, since both the sun and fixed stars are held to be motionless, in your view, and any apparent motion of either would be attributed to the movement of the earth.

The apparent motion of the sun north and south, although only straying twenty three degrees to both sides of the equator across lines of latitude, is not accompanied by a proportional apparent motion of the fixed stars north and south along lines of latitude. Instead, we find the fixed stars rising and setting over the same latitudinal lines of the earth throughout the course of the year, and the northern celestial pole remaining fixed at the tail of Ursa Minor. So also, according to your view, if, as we do, we find the fixed stars rising and setting over the same lines of latitude of the earth, we should also find the sun rising and setting over the same lines of latitude, and we should then find no variation of seasons. But we find the sun rising and setting over a great variety of latitudinal lines, straying from the equator by twenty three degrees towards the north and by the same amount towards the south.

Thus, there is no congruence between the apparent motions of the sun and fixed stars, which there would have to be, if both were motionless, and any of their apparent motions had to be attributed to the movement of the earth. If the earth tilts or passes south and north of the sun along its course through the zodiacal signs around the sun, there should be a corresponding apparent variation in the fixed stars according to latitude. The motion of the earth could not, if the sun and fixed stars were both motionless, be responsible for a change in the sun's position northward and southward across lines of latitude, without also causing an equivalent variation across latitudinal lines of the fixed stars, and of the northern celestial pole. There is no way of getting around this. I have set for you a sort of riddle of the sphynx. Or, better yet, I have unraveled the riddle of the sphynx which consisted in your confounding obscurities.

Galileo: This problem is, indeed, one of those sorts of riddles. For, as I said in my *Dialogue Concerning the Two Chief World Systems*, that, not only none of them ever applied himself to making such observations, but I am not even sure that any of them knew what variation ought to be produced in the fixed stars by the annual movement of the earth.[125] And again that, I do not believe that anyone has set himself the task of observing whether variations which might depend upon an annual movement of the earth are to be perceived in any fixed star at the various seasons of the year, and I added that I doubt whether anyone has very clearly understood just what variations should appear, or among what stars. And I said that I have indeed found authors writing in general terms that the annual motion of the earth should not be admitted because it is improbable that visible changes would not then be seen in the fixed stars. Not having heard anyone go on to say what, in particular, the visible changes ought to be, and in what stars, I think it quite reasonable that those who say generally that the fixed stars remain unchanged have not understood and perhaps not even tried to find out the nature of these alterations, or what it is that they mean ought to be seen.[126] Also, the question is one which Copernicus himself despaired of explaining in such a way as to make it intelligible, as will be seen both from his own admission of its obscurity and from his setting out twice to explain it, in two different ways.[127] And without affectation I admit not having understood his explanation myself. I have, however, given much consideration to the problem, and if you let me gather my thoughts, I will recount to you my solution in preservation of the Copernican worldview.

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[125] *Galileo. Dialogue Concerning the Two Chief World Systems*. III. Pg. 372

Simplicius of Cilicia: Take your time, then. In the meantime, how do you deduce that the sun and not the earth is the center of the revolutions of the planets? You would be wise to resort to certainty and proof rather than probability and likelihood.

Galileo: This is deduced from most obvious and therefore the most powerfully convincing observations. The most palpable of these, which excludes the earth from the center and places the sun there, is that we find all the planets closer to the earth at one time and further from it at another. The differences are so great that Venus, for example, is six times as distant from us at its furthest as at its closest, and Mars soars nearly eight times as high in the one state than the other.[128] And these are signs that they move around the sun, since their distance from the earth would otherwise be invariant. This is reasoned out from finding that the three outer planets—Mars, Jupiter, and Saturn—always quite close to the earth when they are in opposition to the sun, and very distant when they are in conjunction with it. This approach and recession is of such moment that Mars when close looks sixty times as large as when it is most distant.[129] Next, it is certain that Venus and Mercury must revolve around the sun, because of their never moving far away from it, and because of their being seen now beyond it and now on this side of it, as Venus' change of shape conclusively prove.

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[126] *Galileo: Dialogue Concerning the Two Chief World Systems*. III. Pg. 377, 378

[127] *Galileo: Dialogue Concerning the Two Chief World Systems*. III. Pg. 379

Simplicius of Cilicia: Stop there, Galileo. How can you tell that any of the planets are at one time nearer to us and at another time further? I know not the meaning of this, and I disagree entirely.
Galileo: These things can only be comprehended through the sense of sight, which nature has not granted so perfectly to men that they can succeed in discerning such distinctions. But in our time, it has pleased god to concede to human ingenuity an invention so wonderful as to have the power of increasing vision four, six, ten, twenty, thirty, and forty times, and an infinite number of objects which

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[128] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 321

[129] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 322

were invisible, either because of distance or extreme minuteness, have become visible by means of the telescope.[130]

Simplicius of Cilicia: But Venus, Mars, and the other planets, are not objects which are invisible because of any distance or small size. We perceive these by simple natural vision. Why, then, do we not discern the differences in their sizes and shapes?[131] Without a telescope there is no difference or variation in brightness whatsoever, not in the slightest bit, of any of the planets in any of their positions. Only by their proximity to the glow of the sun, if near to the horizon around dawn or dusk, do the planets seem at all more dim compared to their luminescent appearance when they are well above the horizon on a moonless night—in the same way that all of the stars appear less bright during the twilight hours of dawn and dusk. Is that what you mean, that their brightness is dimmed when observed in proximity to the horizon just before dawn or just after dusk—and from their relative dimness when in conjunction with the sun you infer that they are further away from us, compared to their distance from us when they are three, four, five, or six zodiacal signs away from the sun?
Galileo: Yes, that is the observation I refer to.

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[130] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 335

[131] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 335

Simplicius of Cilicia: Well, I should wonder if your observations were made when any of the planets were in proximity to the full moon, if you would thereby infer from their seeming less bright at that time, that they had fallen away from us however many times their usual distance for a night or two, then once the moon passed the visual field of their proximity, that they had returned to a closer distance to us. I should also wonder if your observation around the time of a full moon result in your inferring that each of the planets and stars are further away, for being outshone in brilliance by the light of the shining moon.
Galileo: Are you being ironic?
Simplicius of Cilicia: Is that not the same phenomenon as you observe when, as you say, the planets appear more distant from us when they are in conjunction with or near to the sun, and that they appear close to us when they are in opposition to the sun? Is the case not the same when they are in conjunction with the moon, and both are in the same visible field?
Galileo: I don't think they are the same phenomena.

Simplicius of Cilicia: Well, is there any other measure you use to determine the distances of these objects than their observed brightness? From what I can tell, that is your measure.
Galileo: That is precisely the method by which we measure the distances of the planets.

Simplicius of Cilicia: Is that not in contradiction with the order of the planets themselves? Mercury, the nearest planet, is the dimmest and least bright of all, requiring a trained eye to even locate. And compared to Venus, the next planet after Mercury, his brightness

is as nothing, yet Mercury is nearer—although I know you want to dispute their position, and now I understand why. I wish to avoid changing the subject, for now. As that example is wrought with a further dispute, consider Mars and Jupiter. Mars is, by both of our perspectives, closer than Jupiter, yet Jupiter is immensely more brilliant, and Mars dimmer. You would suggest ordering the planets according to brightness, or you would have to arrange Jupiter the nearest to us after Venus, and you would have to arrange Mercury even beyond Saturn—and that is a wonder for the results of your method, how the nearest and furthest are the two least bright planets. Why then do you consider their brightness to indicate their distance? You might as well arrange them by color, and place Mars first for reason of having a hue as red as blood, and place Jupiter far away for reason of the blue glow that surrounds him.
Galileo: Once their order and arrangement are established, a variation in the brightness of one of them would indicate a change in distance. You must agree at least with that much.

Simplicius of Cilicia: I would certainly not agree if they were positioned at the time observed just above the eastern horizon at dawn or the western horizon at dusk, and you had not a chance to observe them during the mid of night— if they rose immediately before sunrise or set immediately after sunset, never on that night occupying the visible field during the dark hours of the night outside of your observation of them at twilight. I would then consider your observation of their change in brightness to indicate nothing about their distance, and attribute your observational results to their only occupying the visual field during the glow of twilight, and setting immediately after the sun or rising immediately before the sun. Such a timed observation has great value if you are tracking the heliacal rising of a fixed star, or attempting a rare glimpse at Mercury, but not in the observation of a planets brightness to be equated as commensurate with their distance. If, however, you made your observation when the planet was a right angles with the sun, and again when it was in opposition to the sun, and there was some significant difference in brightness, you might be worth listening to—not when you say, that the planets are closer to the earth when they are in opposition to the sun, and very distant from us when they are in conjunction with it. For, I am sure that when they are at right angles with the sun they appear equally as bright as when they are in opposition to the sun, and the only time there is any variation in their brightness is when they rise over the eastern horizon just before sunrise and when they set over the western horizon just after sunset—when you have not the chance to make a proper observation of their brightness without the hinderance of the afterglow of twilight, or, in another case, without the hinderance of moonlight, both of which resulting in a perceived decrease in brightness of any one of the planets under those conditions.

Galileo: I assure you that the variation in brightness and dimness is not due to the lingering glow of the setting sun or the equivalent phenomenon of the oncoming rising sun. You, who are not acquainted with our instruments cannot contend with us about their results. For, without a telescope it cannot be comprehended that Mars does increase sixty times and Venus forty times in one position as against another, and their differences in distance appear to be much less without these accurate instruments.[132]

Simplicius of Cilicia: I don’t think that there is any difference or variance in the brightness, and I know not what you mean by difference in distance if not by that, of any of the planets, unless, as I said, they only show themselves in the night sky just over the eastern horizon at dawn, or just over the western horizon at dusk. And I am pleased with your admission of this one thing, that without a telescope the peculiar phenomena about irregular distances and, I might add— your unusual claim about Venus’ crescent shape to claim that she is not self-luminescent,[133] when by unaided natural vision she is always seen to be full and resplendent, brighter than any of the fixed stars and second in brightness only to the sun, as well as the moon when the moon is illumined—that all of these claims have no basis if not for your telescope.

Galileo: And you discount our observations?
Simplicius of Cilicia: Although I would like to say that you are fiddling over illusions of the lenses of your

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[132] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. 372, 373

[133] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 322

telescope device,[134] I need not introduce a conflict regarding the usefulness of your instruments. I only need to hold the position that brightness is neither equivalent to nor commensurate with distance, regarding the planets and stars, in order to deny your claim that you observe the planets closer to the earth at one time and further from it at another time. As I have already explained the cause of this phenomenon—your observation of planets appearing less bright when in conjunction with or near to the sun— and that this has nothing to do with distance, but rather with being drowned out by the afterglow of daylight when they are only visible barely above the horizon for at most a couple hours, and their not showing themselves against the pure darkness of the night sky, to provide for a comparable observation, I will now talk about the only measure of distances of the luminaries.

There cannot be a more suitable way for us to order the celestial spheres than by arranging them according to the variations of their periodic times, putting the slower further than the faster, and the faster nearer than the slower.[135] That is, unless we are fortunate enough to witness the passing of one in front of another, as we might see the moon pass in front of Mars or some other planet, indicating to us that the moon is nearer to us than Mars and that he is further from us than she. We have made many such observations ourselves, on top of those described by the Greeks, and similar accounts of those events are given by the Egyptians and Babylonians, whose observations have been kept for very many years past, and from whom much of our evidence about particular stars is derived.[136] However, that observation is not available for all of the planets as regard to each other.

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[134] *Galileo. Dialogue Concerning the Two Chief World Systems.* I. 53, III. 336, III. 353

[135] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. 366

The problem of the distances of the planets is filled with difficulty, because there is not another stable variable, besides the rate of periodic cycles for our employment of mensuration, as their difference in brightness from one another is unrelated to their distances—for, Mercury, the nearest of all the planets, or in your view the second closest, appears much less bright than Jupiter, as well as than Mars and perhaps even Saturn, and undoubtably less bright than Venus. I don't know what else you can use as a measure to find the distances of the planets. You'd better leave off aiming at a hyper-precise mensuration of their distances. The only measure of their distances is the relative timing of their completion of their periodic cycles, alongside the occasional witnessing of one of them passing in front of another. Beyond the somewhat obvious relations amongst them derived from those means, any specification using what I call hyper-precise estimations of their distances by decimals is futile and vain. There is not even the slightest variation of brightness of any of them that is detectable to the unaided natural eye, besides the apparent dimness caused by the dawn or dusk, which is as much common to the fixed stars as to the planets—which is the cause of difficulty of observing heliacal risings.

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[136] *Aristotle. De Caelo.* II. 12. 292a, 1-10

Galileo: Then, as we cannot reach agreement about the distances of the planets, we ought to return to the challenge you posed to me, as I have somewhat gathered my thoughts about the change of polar altitude as a result of the annual motion of the earth. And although I consider this an ongoing problem and requiring further speculation, there are a couple ways of navigating through the challenge.

Simplicius of Cilicia: I would gladly turn the conversation back to the point we left off at. For, these other problems are but particulars, which would require yet others to revolve around to a conclusive demonstration of an affirmation of one or the other of our perspectives regarding the arrangement of the cosmos. How, then, do you propose to go about resolving the problem I set for you?

Galileo: As I said, there are a few avenues which I consider likely to unravel the problem without inhering contradiction. The first I mentioned before, that the poles, the axis, the equatorial plane, and the parallels referred to as latitudinal lines—all these things are in the earth, and not in the stellar sphere, that being immovable and devoid of all such things, and it is only in imagination that they can be pictured there by prolonging the axis of the earth to where its termination would designate two points placed over our own poles, and extending the equatorial plane so that there would appear to be a circle in the sky corresponding to it. Now, if the true axis, the true poles, and the true terrestrial equator do not change on the earth so long as you stay at the same place on the earth, you may take the earth anywhere you please without ever changing your own location with respect to the poles, or to these circles, or to any other terrestrial thing. And as you do not change place with respect to the earth's poles, that is, in such a way as to raise or lower them, likewise you will not change place with respect to the poles imagined in the sky, so long as we mean by "celestial poles" those two points which would be marked by the terrestrial axis when prolonged in the sky.[137] It is true that such points in the heavens are changed when the transposition of the earth is carried out in such a way that its axis points to other parts of the immovable celestial sphere, but our situation with respect to them would not be changed so that one would be elevated more than the other. Whoever wants one of the points in the firmament corresponding to the earth's poles to move upward and the other downward must travel along the earth toward one and away from the other. Nothing is accomplished by transposing the earth and ourselves along with it, as I have said.[138]

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[137] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 374

[138] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 374, 375

Simplicius of Cilicia: You seem to me to be saying two different things. I have already addressed your claim that there is no substantial basis for the celestial poles, which you say are imaginary extensions of the axis of the earth projected to the firmament. I ought to repeat that, regardless, the problem at hand is to account for the apparent motion of the fixed stars, which would sway north and south if, like you say, the firmament and the sun are both motionless, and both of their apparent motions have to result from and be caused by the earth's own movement.

In all cases, the celestial pole appears to be unmoved and fixed directly over the axis of the earth, which is inevitably part of the formula required to determine which of the two, the earth or the sun, is in motion and which at rest. Your statement that there is no reality to those parts of the heavens should be referred back to the first part of our conversation. Besides that, you say that the transposition of the earth throughout the cosmos does not and could not affect the apparent position of the poles and circles of latitude imagined in the sky, so long as you don't change your position on the earth. I must overlook this rash statement and draw attention to your other remark. You say that, in contradiction to the prior statement, that such points in the heavens are changed when the transposition of the earth is carried out in such a way that its axis points to other parts of the immovable celestial sphere. And if I understand at all your meaning, you fall back into the alternate contradictory again when you claim that only by travelling along the earth toward or away from the poles of the earth do the celestial poles appear to move upward or downward in the sky. First, do we agree

that the apparent motion of the fixed stars is one of the elements of the problem? I wish to avoid your writing off the structure of the heavens as illusory, as toiling over that would only distract us from the problem we are involved in already.
Galileo: You may overlook that statement, however, that is at the root of our disagreement.

Simplicius of Cilicia: Then for now we have the task set in front of us to account for the apparent motion of the heavens, along with that of the sun, in question of whether the motion of the sun or the earth is responsible for them, for we agreed that one of the two must be the cause of those apparent motions. Be good enough as to answer if you agree with this. I do not think that you would deny to me that if we were to travel only sixty miles to the north along the face of the earth, the celestial pole would rise one degree; and likewise, another sixty miles to the north, the pole would be raised for us another degree, etc.[139]
Galileo: Such a pattern of our motion in increments of sixty degrees would result in observing the northern celestial pole as raised up a single degree each time, yes.
Simplicius of Cilicia: There is much change, indeed, in the stars which are overhead, and the stars seen are different as one moves northward or southward. For, there are some stars seen in Egypt and in Cyprus which are not seen in the northerly regions; and stars,

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[139139] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 373

which in the north are never beyond the range of observation, in those regions rise and set.[140]

Now, if such minimal change of our position to the north or south on the earth causes a manifest alteration in the horizon, —I mean, if moving toward or away from the celestial pole a mere sixty miles upon the surface of the earth produces such an effect on the apparent position of the pole star, as well as on the northward and southward position of the rest of the fixed stars, then wouldn't even the slightest rotation or tilt of the earth resulting from its oblique orbital path likewise result in an obvious change in the position of the northern celestial pole star, Polaris?[141]

Galileo: Not if the distance is so great between the fixed stars and the earth that the orbital path of the earth around the sun is rendered null.[142] If the cosmos is infinite no fixed ratio could determine a correspondence between the path of the earth through its orbit and the fixed stars.
Simplicius of Cilicia: Leave off this divergent consideration about whether or not the cosmos is

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[140] *Aristotle. De Caelo.* II. 14. 297b, 32- 298a, 5

[141] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 373

[142] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 386, 387

infinite. If you wish, I will prove the contrary to you afterwards. We ought to reach an agreement about concentric circles before considering what amount of distance would render the motion of one body within another's as having no effect.

Galileo: Then let us continue with the speculation about concentric circles, if that isn't also a divergence.
Simplicius of Cilicia: No that is not a divergence. We will need use what we gather here in what unfolds from the same problem.

Consider if, with concentrically described circles about the same centre, the innermost and outermost circumferences, regardless of their distance, trace out the same three hundred and sixty degrees? Or, if you suppose, on the contrary, that a larger circle contains more angular space than a smaller circle, and that they both don't contain an angular space equal to four right angles?
Galileo: A greater circle contains the same amount of angular space as a lesser circle, and no more.

Simplicius of Cilicia: Then tell me, concerning concentric circles, if the innermost circle revolves around, bringing a point along its circumference to a position at right angles to that point's original position, does that quarter turn of the lesser circumference also cover a quarter of the total angular space contained by the greater circle with the outermost circumference?
Galileo: A quarter turn of the innermost circle would cover the same amount of angular space as a quarter turn of the outermost circle.

Simplicius of Cilicia: And if two points are aligned at the same degree of each of the circumferences, one on the innermost and one on the outermost—does a half turn of the lesser circle bring the point that was in alignment from conjunction with the point on the greater circumference to a position of opposition with the point it was aligned with?
Galileo: Yes
Simplicius of Cilicia: And the point on the lesser circumference will have covered half the angular space of the greater circumference, as well as its own, by reaching the position opposite to the point on the greater circumference?
Galileo: Yes
Simplicius of Cilicia: And will have thereby covered the same amount of angular space contained by the greater circumference as it covered within its own circumference?
Galileo: That is right.

Simplicius of Cilicia: Then, a forty-seven degree rotation of the earth would turn its axis an equal amount of angular space contained within the sphere of the fixed stars from whatever star it aligned with previously to a star forty-seven degrees away from that. Is that agreeable?
Galileo: If the earth were shown to rotate thus, that would be the result.
Simplicius of Cilicia: And if, along the annual course of the earth around the sun, which is oblique to the axis of the earth and the equatorial line, the axis of the earth is brought around to point away from the northern celestial pole, would that not result in an

obvious change of the apparent position of the northern celestial pole?
Galileo: If that were the case, yes.
Simplicius of Cilicia: Especially if moving sixty degrees north or south results in a change of the altitude of the celestial pole by one degree—there would be a considerable change in the apparent altitude of the celestial pole if the axis of the earth were to be displaced to point elsewhere along the earth's annual course while moving at an oblique angle to its axis and to the equatorial line. I should remind you that we observe no displacement of the celestial pole from *stella polaris*.
Galileo: Yes, however you are mistaken about the magnitude of the apparent variation in altitude of the pole star. Wouldn't a greater circumference require a greater distance to be traversed in order to result in the same difference in angular space than would a lesser distance traversed around a lesser circumference?

Simplicius of Cilicia: Well, as glad as I am that you have come around to agree with me that a slight rotation, tilt, or change of direction of the point of the earth's axis during its annual course around the sun, would result in an obvious change in altitude of the pole star and the rest of the fixed stars, I am unsettled by your posing an opposite problem to me, from the opposite perspective. I feel as if I am being sent out to hunt rabbits.[143] Before you argued that the movement of the earth around its centre would result in no apparent change in the latitudinal risings and settings of the fixed stars, because of the difference in magnitude and great distance between the earth and the fixed stars. Now, you argue that a movement along a greater circumference, the orbit of the earth around the sun, would result in less apparent change in the altitude of *stella polaris*, for the reason that the same distance covered along a greater circumference corresponds to less angular degrees than that distance covered along a lesser circumference.

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[143] *Herodotus. Histories.* IV. 134

My argument, however, requires no such resolution regarding these new problems. I have only set out to argue that there must be an obvious apparent change in the altitude of *stella polaris* if the axis of the earth points away from that star during its annual course obliquely around the sun. Thus, if the movement of the ship a mere sixty miles makes a fixed star rise one degree for me, why shouldn't a similar change, and even a much greater one, happen for me when the ship is transported toward the same star by such a space as the diameter of the earth's orbit, which you must agree is double the distance of the earth from the sun?[144]

Galileo: I suppose I will make a concession to some of these particulars, but without renouncing the Copernican worldview. I have been influenced by knowing that the annual movement attributed to the earth by Copernicus, if made perceptible in the stellar sphere, would not produce visible alterations equally among all of the stars, but would necessarily make great changes in some, less in others, still less in yet others, and finally none in some stars.[145] The alterations which should be seen, then, are of two sorts; one is an apparent change in size of these stars, and the other is a variation in their altitudes at the meridian, which implies as a consequence the varying of places of rising and setting, of distances from the zenith, etc.[146]

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[144] *Galileo. Dialogue Concerning the Two Chief World Systems*. III. Pg. 376

Simplicius of Cilicia: Please don't bother me about the apparent change in size of stars, as I don't wish to fall back to our intermediate argument. Go on about the variation of altitudes, places of rising and setting, and distances from the zenith—our current topic, which I assume you will try to resolve, after denying as far as you possibly could that those things would result from an arrangement of the cosmos with the earth moving around the sun.

Galileo: I told you that I don't think this problem has been thoroughly considered. I will provide a detailed explanation of the phenomena that we should expect to see, under the hypothesis of the earth's annual cycle around the sun, much of which you have already explained. Then I will say why those apparent motions in the positions of the fixed stars have not been observed. For, I think that I can either show that those effects are too minute for observation, or that they could be observed but only with great difficulty. This, then, is my personal attempt at a solution.

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[145] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 378

[146] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 378

Before which, I will provide an overview of the motions of the earth that are responsible for the peculiar results in question. There are the annual and the diurnal motions of the earth—the former must be understood to be made by the earth in the circumference of its orbit, which is a large circle described in the plane of the ecliptic. The other, the diurnal, is made by the earth's globe upon itself around its own center and axis, and not vertical to the plane of the ecliptic, but inclined to that with a tilt of twenty-three and a half degrees, which inclination is maintained throughout the year. And what must be especially noted, is that it keeps this tilt always toward the same part of the sky, so that the axis of diurnal motion is maintained always parallel to itself.[147] Hence, if we imagine this axis prolonged all the way to the fixed stars, then while the earth is going around the whole ecliptic in a year this axis describes an oblique cylindrical surface, which has for one of its bases the said annual circle, and for the other a similar imaginary circle traced by its extremity—or let us say its pole—among the fixed stars. This cylinder is oblique to the plane of the ecliptic according to the inclination of the axis which describes it, and this we have said to be twenty-three and a half degrees. This remains perpetually the same except for some small variation in many thousands of years, which is not significant in the present connection. Thus, the terrestrial globe neither tilts further nor straightens up, but is kept immutable.[148]

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[147] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 379

Now, I say, first, that none of the fixed stars in the ecliptic will ever vary in elevation no matter what motions the earth makes in the plane of the ecliptic, but will always be perceived in the same plane, though they will approach and recede from the earth by as great a space as the diameter of the earth's orbit.[149] Then, I say that the alteration of appearance, which, using the proper technical term, we may call the parallax of the fixed stars, is greater or less according as the stars observed are more or less close to the pole of the ecliptic, and that finally for stars on the ecliptic itself, the alteration is reduced to nothing,[150] while the angle of difference of the polestar is the maximum; of the others, those closest to this maximum are larger than those more distant from it.[151] Again, the elevation or lowering is nil for stars along the ecliptic and large for those encircling the pole of the ecliptic, being intermediate for those in the middle.[152]

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[148] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 379, 380

[149] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 380

[150] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 384

[151] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 383

It is possible, Copernicus declares, that the immense distance of the starry sphere makes such small phenomena unobservable. And as has already been remarked, it may be that up to the present they have not even been looked for, or, if looked for, not sought out in such a way as they need to be; that is, with all necessary precision and minute accuracy. It is hard to achieve this precision, both on account of the imperfection of astronomical instruments, which are subject to much variation, and because of the shortcomings of those who handle them with less care than is required.[153]

Now, I have worked out a sufficient mathematical demonstration of what we should expect to see—that there would be a greater alteration in the latitudinal markings of some stars than in others due to the earths annual course around the sun. If you would like to hear it, I will describe in detail what we should expect to find resulting from the hypothesis of the earth's motion around the sun.
Simplicius of Cilicia: Yes, please go on with your demonstration.

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[152] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 385

[153] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 387

Galileo:

We can pass over the demonstration that the stars along the ecliptic experience no raising and lowering due to the earth annual movement around the sun. Let us now go to the fixed stars outside the ecliptic, and assume a great circle vertical to its plane, for example a circle that would correspond in the stellar sphere to the solstitial colure. This we shall mark CEH, and it will be a meridian at the same time. Let us take in it a star outside the ecliptic, which can be E here. Now this will indeed vary its elevation with the movement of the earth, because from the earth at A it will be seen along the ray AE, with the elevation of the angle EAC, but from the earth at B it will be seen along the ray BE, with an angle of elevation EBC. This is greater than EAC, on account of its being an exterior angle of the triangle EAB, while the other is the opposite interior angle. Hence the distance of the star E from the ecliptic would be seen to be changed, and also its meridian altitude would be greater in position B than in the place A, in proportion as the angle EBC exceeds EAC; that is, by the angle AEB. For the side AB of the triangle EAB being produced to C, the exterior angle EBC (being equal to the two opposite interior angles E and A) exceeds A by the size of the angle E. And if we take another star in the same meridian farther from the ecliptic — let this be the star H — then this will be even

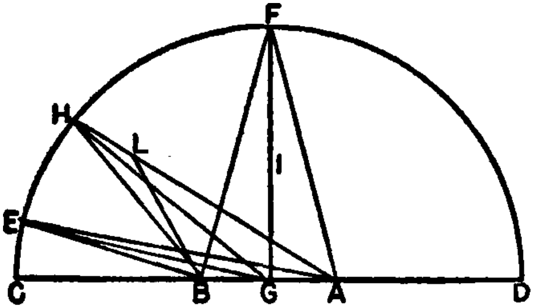

FIG. 25

greater in variation when seen from the two positions A and B, according as the angle AHB becomes greater than the angle E. This angle will continue to increase in proportion as the star observed gets farther from the ecliptic, until finally the maximum alteration will appear in that star which is placed at the very pole of the ecliptic. For a complete understanding, this may be demonstrated as follows:

Let the diameter of the earth's orbit be AB, whose center is G, and assume it to be extended out to the stellar sphere in the points D and C. From the center G, let the axis GF of the ecliptic be erected as far as the same sphere, in which a meridian DFC vertical to the plane of the ecliptic is assumed to be described. Taking, in the arc FC, any points H and E as places of fixed stars, add the lines FA, FB, AH, HG, HB, AE, GE, and BE. Then AFB is the angle of difference (or we may say the parallax) of the star placed at the pole F; that of the star at H is the angle AHB, and for the star at E it is the angle AEB. I say that the angle of difference of the polestar F is the maximum; of the others, those closest to this maximum are larger than those more distant from it. That is, the angle F is greater than the angle H, and this is greater than the angle E. Suppose a circle described about the triangle FAB. Since the angle F is acute, its base AB being less than the diameter DC of the semicircle DFC, it will fall in the larger portion of the circumscribed circle cut by the base AB. And since AB is divided in the center and at right angles to FG, the center of the circumscribed circle will be in the line FG. Let this be the point I. Now of all the lines drawn to the circumference of the circumscribed circle from the point G, which is not its center, the greatest is that which passes through the center. Hence FG will be greater than any other line drawn through G to the circumference of the same circle, and therefore this circumference will cut the line GH, which is equal to the line GF, and cutting GH it will also cut AH. Let it cut that in L, and add the line LB. Then the two angles

AFB and ALB will be equal, being included in the same portion of the circumscribed circle. But ALB, an exterior angle, is greater than the interior angle H; therefore, angle F is greater than angle H.

By the same method we may show that the angle H is greater than the angle E, because the centre of the circle described about the triangle AHB is on the perpendicular GF, to which the line GH is closer than the line GE; hence its circumference cuts GE and also AE, from which the proposition is obvious.

From this we conclude that the alteration of appearance— which we may call the parallax of the fixed stars— is greater or less accordingly as the stars observed are more or less close to the pole of the ecliptic. The angle of difference across latitudes is greatest for those stars verging on the polar region, while for stars on the ecliptic itself the alteration is reduced to nothing. That is, the elevation or lowering is nil for stars along the ecliptic and large for those encircling the polar region, being intermediate for those in the middle.[154]

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[154] Demonstration taken directly without alteration from— *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 383, 384, 385

Simplicius of Cilicia: That is all well and good, Galileo. However, why do we not observe those apparent changes? That, remember, is my point, that if the earth were to move around the sun, then we ought to observe the position of the fixed stars to alter across lines of latitude. Now, you have admirably demonstrated some particulars regarding what those apparent changes would amount to, yet it is up to you to explain why they are imperceptible and pass unnoticed.

Galileo: And my answer is that, because the distance of the fixed stars from the earth is so vast, the alterations just explained would have to remain entirely imperceptible in them.[155] Or, if perceptible, then only by the means of the right astronomical instruments.

As I said before, and as Copernicus declared, the immense distance of the starry sphere makes such minute phenomena unobservable,[156] and it may be that up to the present day they have not even been looked for, or, if looked for, not sought out in such a way as they needed to be; that is, with all necessary precision and minute accuracy. It is difficult to achieve this precision, both on account of the imperfection of astronomical instruments, which are subject to variation, and by fault of their misuse.[157] Besides which, it is almost impossible for the instrument to be constructed absolutely accurately and then maintained so. Ptolemy distrusted an armillary instrument constructed by Archimedes himself for determining the entry of the sun into the equinox.

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[155] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 386

[156] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 387

Now, my idea is for us to make observations of the fixed stars with instruments which would require improving upon those currently available.[158] And if in the course of these operations any such variation shall happen to become known, and we have ascertained the annual motion, how great an achievement will be made in astronomy![159] Would you be convinced if those alterations really were perceived in the stars which seem to you so necessary if the annual motion belongs to the earth?[160] You must agree that, if such a variation were perceived, nothing would remain that could cast doubt upon the earth's mobility, since no counter could be found to such an event.[161]

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[157] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 387

[158] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 388

[159] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 389

[160] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 386

Simplicius of Cilicia: I think you have only made the task more difficult for yourself, Galileo. I wish to avoid letting the entire argument hinge on our disagreement about scientific instruments. I don't think that could be conclusive for either of us.
We have agreed, have we not, about the properties of concentric circles and the equal angular space of a greater encompassing circle covered by a rotation of the lesser circle?
Galileo: Yes, we have agreed about that. However, that is not entirely relevant if the axis of the earth remains pointing toward the polar region in its course around the sun. For, the circumference described by the earth in its annual course does not correspond to the turning of a lesser concentric circle, if the direction the axis of the earth points to is not pulled around the circumferential path of its orbit around the sun.
Simplicius of Cilicia: Of course the axis of the earth remains pointing perpendicular to the equatorial line, and the path of the ecliptic runs obliquely across that, as you yourself say and as we agree. Let us take your model of the relevant arrangement and phenomena. I refer to your description of a cylinder with its base as the circumferential path of the earth's motion around the sun, and an equivalent circle described by a projection of the directional point of the earth's axis throughout the annual course, equal to the base of the

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[161] *Galileo. Dialogue Concerning the Two Chief World Systems*. III. Pg. 386, 387

cylinder. I think our argument should resume that direction of thought.
Galileo: Okay, go ahead.

Simplicius of Cilicia: If the diameter of the earth's orbit spans twice the distance as that between the earth and the sun, and the axis of the earth would point to and carve out a circle around the celestial pole that would be equal in area to the earth's orbit, then we should expect to find that the celestial pole shifts as much as the span of the circumference of the earth's orbital path, which is twice the distance as the earth is from the sun. Is that right?
Galileo: Yes, but that might cover a minute and fractional area of the celestial sphere, the fixed stars being at such a great distance from us.
Simplicius of Cilicia: Well, we agree that the axis of the earth would be brought to point the width of an angle of some degree of distance around the outer circumference of fixed stars while revolving around the inner circumference of the earth's orbital path around the sun, even if, as we agree, the earth's axis remains fixedly pointed perpendicularly to the equatorial line, and traces a path oblique to that. Right?
Galileo: Yes

Simplicius of Cilicia: Wouldn't, also, the circumference traced by a projection of the earth's axis along its orbit have a diameter that covers a portion of angular distance along a circle inscribed through the fixed stars north and southward that is equal in area to the diameter of the earth's orbital plane?

Galileo: Yes, but we don't know what the angular distance would be.
Simplicius of Cilicia: Well, if traversing sixty miles north or southward along the face of the earth results in one degree difference in the altitude of *stella polaris*, and we consider the diameter of the circle traced by the projected axis of the earth as having an angle proportional to that, the result will be some definite amount of angular distance between the points of variation of the celestial pole. We have yet to agree whether such variation would be enough to be observable, however.
Galileo: Yes, that is our current dilemma.

Simplicius of Cilicia: Well, if we weren't attempting to observe the northern celestial pole—whether that changes its position or not—and we were attempting to track the alteration along latitudes of some other star, I would be less adamant about the observability of the apparent change under hypothesis. For one, as the rest of the stars appear to circle around *stella polaris*, that star provides a sort of anchor, being unmoved and encircled concentrically by the paths of each of the other stars, so that the northernmost constellations that never appear to dip beneath the horizon trace out parallel circles further or closer to the pole star in proportion to their latitudinal difference away from that point, our observations don't have to rely on the lines of latitude of the earth, and risings and settings thereupon, but can be observed without reference to any of that.

Then, also, we have more than just a single point to track, as the northernmost constellations, not just the pole star alone, would be seen to vary, and be much more obvious. As *stella polaris* is the end point of the tail of *Ursa Minor*, and the circling paths around *stella polaris* are perfectly arranged such that, the northernmost constellation, *Ursa Minor*, with the shape of a bear, appears to rotate around the end of its tail, if the celestial pole were to be displaced from the end point of the tail of the lesser bear, that whole constellation would appear to be thrown off from its path. And since that motion referred to is daily, and each night we have the chance to watch the lesser bear turn around its tail, with its head tracing the outer circumference, and the question of variation of the celestial pole would be over the course of a year, resulting in the greatest distance between variant points at the halfway points of the year, we should see, if the earth moves around the sun, *Ursa Minor* spinning, for half of the year, not around its tail, but around a point somewhere closer to the front of its body, making the end point of the tail revolve around that, so that the head and tail would both revolve around the hindlegs or forelegs, for example, at the opposite side of the year. And such variation of the revolving spin of *Ursa Minor* would be easily observable and would accompany the variation in the position of the celestial pole. That is, with our eyes fixed to the constellations around the celestial pole, and not zoomed in through a telescopic lens to some star not considered as part of a constellation, the observation would be easily discerned, for great changes would occur in *Ursa Minor*, which would rotate not around its tail end, but its head and tail would revolve around somewhere between them, say, the hind or forelegs. And as mentioned, we have no need for instrumental equipment to observe that a significant change occurs throughout the course of the year in the rotation of *Ursa Minor*.

In sum, there is a necessary alteration that would occur, a shift in latitudinal points, of the fixed stars and especially of the north star, if the earth is to revolve around the sun, but we observe no such change.

You attribute the lack of apparent movement of the celestial pole to the great distance from us of the fixed stars, while admitting everything up to that point. Nonetheless, you agree that there would be some alteration in the latitudinal altitude of the pole star, which would not be unmoved, as it appears to be, but would change throughout the course of the year. Your position seems more like an excuse than an argument, and therefore I am not sure how to deal with it.

You say that if the earth revolves around the sun, there would have to be a change and variance in the position of the pole star, after which you say that there is no appearance of such an alteration because the distance of the fixed stars is so great. I admit I am confused about your position more so than about the problem at hand. For our own position is that there would have to be such an alteration in the position of the pole star if the earth did move around the sun, which since there isn't an observable variance in the pole star, the earth cannot move around the sun. You, however, grant us all of that, and then somehow elude our conclusion with the qualification that the resultant effects would be unnoticed, even though they would occur. You had better say that there would be no variation in the position of the pole star, that results from the hypothesis that the earth rotates around the sun, than to admit all of that, and then elusively say they wouldn't or haven't been perceived. And you somehow think that such occurrences could be perceived with proper equipment, after already stating that they are imperceptible. I am at a loss with contending against your position and have long considered the heliocentric model disproved.

Galileo: I told you that the relevant phenomena haven't been thoroughly investigated.
Simplicius of Cilicia: And you suppose that the motionlessness of the pole star hasn't been a primary topic of astronomical inquiry for ages upon ages?
Galileo: Perhaps not properly and not with the right instruments.
Simplicius of Cilicia: Yet that star has guided every navigator of ships, and is by commonfolk alike held to be the only unmoving star in the northern hemisphere.
Galileo: If, however, the alteration in the position of the polestar is barely perceptible, there would be no difficulty with their functional use of it as a sort of celestial compass, and yet, for strictly astronomical purposes would be considered to be at variance in terms of altitude and latitudinal lines.

Simplicius of Cilicia: As far as I am concerned, if the celestial pole has no apparent variation in altitude or latitude then there is no such occurrence, which would have to occur if the earth rotated around the sun, as we agree. You at once both admit and deny that there is such an occurrence of variation in the position of the pole star. You say the alteration is virtually imperceptible, but prevalent nonetheless, and only noticeable, yet so far unnoticed, with scientific instruments which are not yet available. That is, you agree that there would have to be alterations along latitudes of the fixed stars if the earth moves around the sun. We say that since there are no such alterations observed, there is likewise no motion of the earth around the sun. You, somehow, then say that the alterations are minute and fractional and imperceptible, yet admit they occur and that they must occur if the earth moves around the sun; after which you presume that they could be observed with specific instruments which are not yet available.

Galileo: Again, I said this part of the problem has been hitherto uninvestigated, and not only us, but future generations will have to reach a resolution in times distant from ours.
Simplicius of Cilicia: Nonetheless, you admit that, if the earth moves around the sun, there would have to be alterations in the latitudinal risings and settings of the fixed stars, and that there are no such phenomena observed.
Galileo: And for the reasons I stated, that they are either minute and imperceptible or require more precise instruments.
Simplicius of Cilicia: Well, if the motion of the earth around the sun would require visible alterations of the fixed stars, and especially the pole star, north and south across latitudinal line, and there has been no such observation, but the pole star remains unmoved to all observers, then doesn't it result that the earth can't move around the sun?

Galileo: Not if they are imperceptible or their observation has not yet been discovered.
Simplicius of Cilicia: If they are imperceptible then there is no such occurrence, and the pole star and the rest of the fixed stars don't alter and aren't at variance across lines of latitude. And since such an occurrence would have to result from the hypothesis of the earth's annual motion around the sun, but no such occurrence is observable, then the earth doesn't move around the sun. The only position available to you, which I neither understand, is that such alterations have yet to be discovered. And even then, they ought to have been, if they occur at all. And if they don't, then the same result follows—the earth can't be in motion around the sun.

Galileo: I should reiterate that I am treating this as an open problem not yet investigated by Copernicus or anyone else that I am familiar with. I will put forth another attempt at a solution to this difficulty. There is a third motion of the earth, besides the diurnal and the annual motions. This is to keep the axis of the earth tilted and pointed toward the same part of the firmament.[162] I am going to tell you something which deserves your most careful consideration. Far from there being any repugnance or difficulty in it, though it is opposite to the other annual motion, it is naturally suited to any suspended and balanced body you please, and without requiring any cause of motion. Such a body, if carried around along the circumference of a circle, immediately acquires by itself a rotation about its own center opposite to that which carries it around; and the speed of this is such that both motions will finish one revolution in precisely the same time.[163] You may see this wonderful effect, which suits our present purposes so well, by putting into a basin of water a floating ball and holding the bowl in your hand. If you turn around on your toe, the ball will promptly commence to revolve upon itself with a motion opposite to that of the bowl, and will complete its rotation when that of the bowl is completed.

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[162] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 398

Now what else is the earth but a globe, suspended and balanced in thin and yielding air, which, carried around the circumference of a great circle in one year, must indeed acquire—with no other mover—a diurnal spin around its own center, opposite to that annual motion? You will see the effect, but if you proceed to reflect correctly about it you will discover that it is not a real thing, but a mere appearance, and that what looks to you like a revolving about itself is a motionlessness and a conservation of the whole unchanged with respect to everything which remains stationary outside of yourself and the bowl. For if you make some mark upon the ball and consider in what direction this points (toward what part of the wall of the room you are in, or the field, or the sky), you will see that the mark always points the same way during the revolution of the bowl and yourself. But comparing it with the bowl and with yourself (these being moving), it will indeed appear to keep on changing direction and to box the compass in its rotation, with a motion contrary to that of the bowl and yourself. Thus it may be more correctly said that you and the bowl are rotating around the motionless ball than that the latter is turning around in the bowl. In such a manner is the earth suspended and balanced in the circumference of its orbit, and so located that one of its markings (which could be, for example, the North Pole) points toward such-and-such a star, or other part of the firmament, and is kept always directed toward this, despite its being carried around the circumference of its orbit in the annual motion.[164] See then how two simple noncontradictory motions assigned to the earth, performed in periods well suited to their sizes, and also conducted from west to east as in the case of all moveable world bodies, supply adequate causes for all the visible phenomena.[165] The third motion, which keeps the axis of the earth pointed towards the celestial pole, is guided by magnetic force, no different than that of the lodestone—and perhaps the earth, as to its internal and primary substance, is nothing but an immense mass of lodestone.

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[163] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 398

Simplicius of Cilicia: Stop there, Galileo. I have two things to say. First, regarding the topic we have been discussing, about the axis of the earth carving out a circumference around the celestial pole equal in area to the earth's orbital path around the sun, and always remaining parallel to the north, throughout shifts around the circumference of its oblique orbit—now you say that the axis doesn't remain perpendicular to the equatorial line, but leans towards the pole star in order to make up for the problem set for you. Remember that the problem so far results from the earth and its axis remaining parallel with itself and perpendicular to the equatorial line, resulting in, due to the vast area of the earth's orbit, the axis of the earth pointing not towards only the north star, but towards an area equal to its orbit around the sun, considered by us as the upper end of a great cylinder, inevitably spanning some angular distance in the firmament which would result in the alteration and variation of the celestial pole around the upper end of that projected cylinder. Now, you were unable to solve that problem, or you would have shown that the axis of the earth doesn't ever point away from the celestial pole during the annual cycle around the sun. You, however, said that the apparent variation of the celestial pole which would have to result from the earth rotating around the sun is imperceptible. We, remember, claim that the earth can't move around the sun because, if it did, there would have to be an alteration in the position of the celestial pole. And since there is no 'perceptible' or observable alteration in the celestial pole, but the pole is always immovably at the tail of *Ursa Minor*, there can be no motion of the earth. Finally, you claimed that the apparent alteration of the celestial pole—which you call 'imperceptible' due to the vast distance between us and the firmament—would, nonetheless, be perceptible if the proper astronomical instruments were employed, which you say, as of yet, are not even available. I must take this as an unwilling concession on your part. For the argument can go no further in that direction. Now, assumedly in an attempt to avoid that fate on your side of the argument, you say that the earth's axis remains fixed to the celestial pole by a third motion of the earth—after the diurnal and annual motions. Consider this, however. Even if the axis of the earth remained aligned to the celestial pole, would not the stars along the ecliptic, near to the equatorial line, stray at variance north and south along the terrestrial equator?

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[164] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 399

[165] *Galileo. Dialogue Concerning the Two Chief World Systems.* III. Pg. 396

Galileo: How do you mean?

Simplicius of Cilicia: Well, in order for the earth's axis to remain pointing towards the celestial pole while being carried around the circumference of its orbit, the earth would have to tilt inward toward the northern celestial pole, to make up for its motion along a circumference with a diameter equal to twice the distance of the earth from the sun. Is that not so?

Galileo: I suppose so. And, if so, what follows?

Simplicius of Cilicia: This third motion, tilting in order to remain pointed toward the celestial pole, would, although keeping the axis of the earth pointed toward the celestial pole, meanwhile alter the equatorial line of the earth, which would have to shift northward and southward to the proportional degree as the corrective tilt of the axis pointed inwards towards the celestial pole. That would have to result in an alteration of latitude of the fixed stars near to the ecliptic and equatorial line. Some constellations in that region would cease to be visible for half of the year, and we would observe the dog star *Canis Major* to sink towards the southern horizon in one season, then in another part of the year rise to a latitude higher in the sky from the perspective of northerners, and thereby assume a greater altitude. But, again, the same stars rise and set over the same parts of the earth, as Aristotle says in support of his argument. So, whether the axis of the earth remains parallel to the equatorial line or leans in toward the celestial pole, variations necessarily would result in the latitudes of the risings and settings of the fixed stars, whether along the ecliptic or verging on the polar region. For, if the axis of the earth doesn't correctively lean towards the celestial pole, but carves out around that a circumference equal in area to its orbital path around the sun, there would inevitably result a shift and variation in the altitude of the celestial pole, from which we would easily observe a change in the rotation of *Ursa Minor*, which we don't—but the lesser bear always turns around the end point of its tail, never turning around its center—and that is invariant throughout the course of the year. Then, if the axis of the earth makes up for that problem by tilting in towards the celestial pole, in the course of its orbit around the sun, such a corrective tilt would result in the axis of the earth no longer remaining perpendicular to the equatorial line. That, in turn, would result in a variation in latitude of the rising and setting of stars near to the ecliptic—as some stars would pass from visibility to latitudes that are too southern to be observed in the north, and then the same stars would pass again into the visual field of latitudes that can be seen from the northern hemisphere, all throughout the course of the year, spanning six months of visibility in the northern latitudes and six months out of sight to northerners, and, then, within the visible field only of those on the southern hemisphere. For, you must realize that a tilting of the earth's axis would result in a tilting of the terrestrial equatorial line in relation to the fixed stars, which then would rise and set over different latitudes. But, again, we observe no change in the positions of rising and setting of the fixed stars, which always show themselves over the same latitudes. So, in either case the same result follows—the motion of the earth around the sun would have to, by requiring more than one motion to account for the celestial phenomena, produce an apparent change in what latitudes the stars rise and set over. Do you follow?

Galileo: I follow the argument.

Simplicius of Cilicia: Then as regard to your other statement. You say that "two simple noncontradictory motions assigned to the earth, performed in periods well suited to their sizes, and also conducted from west to east as in the case of all moveable world bodies, supply adequate causes for all the visible phenomena." I wish to show that those two motions, the diurnal and annual, are, in fact, contradictory. I think I have already sufficiently proven that they don't supply causes that account for the visible phenomena. We obviously agree that the sun appears to traverse the zodiacal signs from west to east, do we not?

Galileo: We do

Simplicius of Cilicia: And your view hold that the cause of that apparent motion of the sun through the zodiac is the earth rotating around the sun—so that the earth is really going through the ecliptic and causing the appearance of the sun going through the opposite signs, right?

Galileo: Yes

Simplicius of Cilicia: Then, do we agree that the earth must be, in that case, moving through the signs from west to east, in the same direction which we observe the sun to pass through them? For, if the earth moved through the ecliptic in the opposite direction from the sun's apparent motion through the ecliptic, they would not keep to the same opposition of signs, but would approach, meet, and pass one another.

Galileo: We agree about that also.

Simplicius of Cilicia: Then, under the hypothesis of the earth's motion around the sun, we are settled about the direction of the earth's path along the ecliptic, that it must be from west to east.

Galileo: Yes

Simplicius of Cilicia: Now, you say that a body in projection around a circumference must have an accompanying and opposite motion around its center—I call this backspin—is that accurate?

Galileo: Precisely

Simplicius of Cilicia: Well, the backspin of a globular body circling from west to east would then be from east to west. Is that right?

Galileo: That seems right.

Simplicius of Cilicia: And the backspin accounts for the diurnal turning of the earth around its center, producing the apparent rising and setting of the stars and luminaries?

Galileo: Yes

Simplicius of Cilicia: And the motion through the zodiacal signs is, of course, the annual motion of the

earth around the sun, under this hypothesis. Is that correct?
Galileo: That is correct.
Simplicius of Cilicia: Then we may continue with the argument, that being settled and reiterated. As for the backspin, we said that must be from east to west, as a counterforce in opposition to the motion of the body from west to east. Do you agree so far?
Galileo: Yes
Simplicius of Cilicia: Then consider this. In order to account for the apparent daily risings and settings from east to west, your theory holds that the earth must be rotating around its own axis from west to east—as, in order for the stars to appear to rise over one horizon the earth must rotate towards that same horizon, in the opposite direction as the apparent motion of the heavens. Is that not what you say?
Galileo: That is what we say.
Simplicius of Cilicia: Well, we agreed that the backspin of a body moving from west to east through the zodiacal constellations would have to be turning in the contrary direction, from east to west, and that this east to west motion of the earth should account for the daily rising and setting of the stars and luminaries. Then, if the stars appear to rise over and from the horizon that the earth sinks towards in its daily turning around its own axis, and we say the daily turning of the earth is from east to west, wouldn't the stars appear to rise and set in the opposite direction, from west to east?
Or if you wish to look over the matter in the other direction, starting with the diurnal motion that accounts for risings and settings and advance to the annual motion—if the earth must rotate around its axis

from west to east, to account for the apparent rising of the fixed stars in the east and their setting in the west, and backspin must be opposite in direction to the primary path of motion of that body, then the direction of the earth should be moving from east to west through the zodiacal signs; and in that case too, the sun would appear to move from east to west through the ecliptic. However, we find that the sun appears to move from west to east through the signs, and the earth must be moving the same direction to account for the apparent change of position of the sun in relation to them. In response to your statement that the two motions of the earth are not contradictory, I say that if the diurnal motion should be a sort of ‘backspin’, then they should, in fact, be made in opposite directions. You, however, must consider the diurnal motion of the earth that accounts for apparent risings and settings to be a sort of top spin, or rolling in the same direction as the primary path of the earth.

Galileo: I suppose I mean the diurnal motion of the earth to be in the manner of a rolling motion, in the same direction as the primary course.

Simplicius of Cilicia: Well, is rolling more appropriate for globular bodies moving on a surface? And is backspin more appropriate for globular bodies projected through the air? Or am I mistaken?

Galileo: That seems right.

Simplicius of Cilicia: But is the earth moving on a surface or through the air?

Galileo: Through the air

Simplicius of Cilicia: And backspin is more appropriate for bodies moving through the air?

Galileo: Yes, that is what we said.

Simplicius of Cilicia: But if the earth's diurnal rotation is backspin, then it will be in the opposite direction of its annual course through the zodiacal signs?
Galileo: That is right.
Simplicius of Cilicia: And the annual course through the zodiac signs is from west to east, unmistakably?
Galileo: Yes
Simplicius of Cilicia: Then the backspin and diurnal rotation of the earth about its centre, resulting in the apparent risings and settings, must be from east to west. Do you agree?
Galileo: I agree
Simplicius of Cilicia: But if the diurnal motion of the earth is from east to west, and the horizon of the earth falls towards the west, then the fixed stars and luminaries would appear to rise over the western horizon and set over the east. Does that not follow?
Galileo: It does.
Simplicius of Cilicia: But the stars appear to rise in the east and set in the west. Do we not agree about that much?
Galileo: Yes, that is the course of the apparent risings and settings.
Simplicius of Cilicia: Then, the earth can have neither backspin as its diurnal motion, nor can it roll. I leave you to consider the result, if then, the earth cannot be moving in more than one motion, which is what the relevant phenomena require if the motion of the earth is to account for them.

Galileo: The argument has worn me out and I am made to feel dizzy and light-headed, like I have been spun around continuously. I am also discontented by having been made to agree by compulsion.

Simplicius of Cilicia: Here, then, is a less rigorous argument for you to contend with, or at least consider, before I let you go. Everyone admits that the moon orbits or revolves around the earth, without question, right?
Galileo: Yes
Simplicius of Cilicia: And everyone also admits that the planets revolve around something in line with the orbit of the moon, that is, through the ecliptic or zodiac signs, such that the moon eclipses the planets as she passes them, just as she does to the sun. You agree, do you not?
Galileo: I agree
Simplicius of Cilicia: Now, the sun appears to traverse the same path of the zodiac and is the same size as the moon relative to perception from earth, as they perfectly eclipse each other. Is that right?
Galileo: That is right
Simplicius of Cilicia: Then, wouldn't the other luminaries with the same course as the moon, only differing in distance and speed, encircle the same centre that we know the moon moves in circles around? As you hesitate, I answer for you that the other luminaries besides the moon must circle around the earth as their centre.

Again, Galileo, this is all in alignment with the observed facts—for, not only does the earth remain at the centre, as we Peripatetics argue, but it moves towards the centre. The place to which any fragment of earth moves must necessarily be the place to which the whole moves; and in the place to which a thing naturally moves, it will naturally rest.[166]

Galileo: We have discussed this part of the argument, yet I often have been able to allude the dilemma, especially at other times, when I am at my leisure.

Simplicius of Cilicia: We agree, however, that the nature of earth is to move from any point towards the centre, as of fire contrariwise to move from the centre towards the extremity, do we not?[167]

Galileo: Towards the centre of the earth, and towards some extremity, at least.

Simplicius of Cilicia: Then, is it not impossible that any portion of the earth should move away from the centre except by constraint?[168]

Galileo: I suppose so.

Simplicius of Cilicia: But isn't it the nature of the whole to move to the point to which the part naturally moves?[169] That is, *Eadem est ratio totius et partium*.

Galileo: I consent.

Simplicius of Cilicia: Then, if no portion of the earth can move away from the centre except by constraint, obviously still less can the earth as a whole so move.[170]

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[166] *Aristotle. De Caelo*. II. 13. 295b, 19-23

[167] *Aristotle. De Caelo*. II. 14. 296b, 26-29

[168] *Aristotle. De Caelo*. II. 14. 296b, 30

[169] *Aristotle. De Caelo*. II. 14. 296b, 34-35

[170] *Aristotle. De Caelo*. II. 14. 296b, 32-35

Galileo: I am compelled to agree.
Simplicius of Cilicia: And do not, also, the parts of earth, not only, as we agreed, move with a power intrinsic to themselves towards the center when projected upwards or suspended in the air by some extrinsic force by constraint, but also find rest upon reaching the center?
Galileo: We observe that, yes.
Simplicius of Cilicia: Then, they might be said to have their natural and unrestrained place of rest at the center?
Galileo: I suppose so.
Simplicius of Cilicia: Then won't the whole of the earth, also, rest unmoved without constraint at the center?
Galileo: According to the argument.
Simplicius of Cilicia: Well, if anything is at rest at the centre, it must have its unrestrained natural motion thereto. Is that right?
Galileo: That is right.
Simplicius of Cilicia: And the parts of earth have unrestrained and natural motion towards the centre, and are only moved away from the centre by a force extrinsic to them and by constraint?
Galileo: Yes
Simplicius of Cilicia: Then, if anything is at rest at the centre, and we agree that something must be, earth, which *partium et totius* has movement without constraint towards, and finds rest upon reaching, that place, must also be unmoved at the centre as regards to the heavenly bodies and the cosmos.
Galileo: Must I respond, or would you not carry on the argument by yourself?

BOOK III.

Pontifex Urban VIII: If I may interject, I believe your response, Galileo, is implied in your preceding admissions. Unless we are to compel your response for our own pleasure at hearing your submission, we ought to consider your answer as implied already. You do, however, have to respond to me. Now, I have a subsequent inquiry about this movement—I mean the scientific revolution—with which you are involved. For as it seems to me, this movement of yours, initiated by Copernicus, attempts to overturn all structures of tradition, and has uncontrollably spread throughout Europe without a centre or guiding agency.

Galileo: How do you wish I respond to you? In the manner in which I was responding to Simplicius, here, or by providing my own account of the issue?

Pontifex Urban VIII: Our discourse should continue however and in whatever way we can come to an agreement about the nature of this social and cultural movement regarding “science”. For I am at a loss about what your ends are and where you derive your inspiration. Your companions in this enterprise are difficult to distinguish, as they blend in with the motives of others who are unlike them in many ways. There has, you know, for two centuries been a fervent impulse towards knowledge, that is *sciens* or *scientia*, in western Europe, a *renascens,* to *renaistre*, upon the rediscovery of the writings of the ancients, both in Latin and Greek. We have, through the Renaissance, rediscovered the classical forms of art, architecture, literature, and politics, and, in a word, the beauty of antiquity. Now, after two hundred years or so of developing whole cities upon the *renascens* impulse towards *sciens*, a peculiar branch has sprung out of this tree of cultural and artistic aesthetics that I have described, which, taking as if by theft the name of ‘science’ has overstepped the bounds of every other branch of the Renaissance modes of culture and education. I mean by this peculiar branch your scientific revolution. First, I should ask you, Galileo, if you consider your science to be different from the forms of *sciens* that were rediscovered two hundred years ago and which have been nourished ever since?

Galileo: Yes, I consider our science to be unique and different from the fields of knowledge available hitherto.

Pontifex Urban VIII: That is evident in the title of another of your works that I have come across as of late, *Discourses and Mathematical Demonstrations*

Relating to Two New Sciences. Presumably, you style these “two new sciences” separately and as different from what has been hitherto called “natural philosophy”, or physics. Since, however, there is a significant amount of overlap in the content you cover with the fields of natural philosophy, that is, physics, and mechanics, there is reason to be confused about what is the proposed content and end of your two new sciences.
Galileo: There is significant overlap between the topics of natural philosophy and mechanics, which you are familiar with, and my two new sciences. However, there is more to account for their differences.
Pope Urban VIII: I daresay that you confound those separate branches of knowledge, or *sciens*, into a conglomerate mass, inartistically, taking each outside of their own domains.
Galileo: Or, perhaps, that I wield them towards a further end.

Pontifex Urban VIII: I, on the other hand, agree with your ‘character’ Simplicius, in your *Dialogue Concerning the Two Chief World Systems*, when he says— “This way of philosophizing tends to subvert all natural philosophy, and to disorder and set in confusion heaven and earth and the whole universe. However, I believe the fundamental principles of the Peripatetics to be such that there is no danger of new sciences being erected upon their ruins.”[171]

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[171] *Galileo. Dialogue Concerning the Two Chief World Systems*. I. Pg. 37

Galileo: And in the following lines Salviati says—"Do not worry yourself about heaven and earth, nor fear either their subversion or the ruin of philosophy. As to heaven, it is in vain that you fear for that which you yourself hold to be inalterable and invariant. As for the earth, we seek rather to ennoble and perfect it when we strive to make it like the celestial bodies, and, as it were, place it in heaven, from which your philosophers have banished it. Philosophy itself cannot but benefit from our disputes, for if our conceptions prove true, new achievements will be made; if false, their rebuttal will further confirm the original doctrines. No, save your concern for certain philosophers; come to their aid and defend them. As to science itself, it can only improve."[172]

Pontifex Urban VIII: I dislike that phrase you use, 'as to science itself', for that can only mean, as far as I can tell, that, as I said, you confound different and separate branches of *sciens* into a conglomerate mass. That is, you are not concerned wholly with the topic and field of natural philosophy, nor with those of mechanics or astronomy, but you confound them all inconsiderately of their proper ends.

Galileo: Science, as Copernicus and I, as well as a great multitude of other minds, have developed, and which is still in the process of development, transcends the bounds of the other and previous forms of knowledge defined and practiced hitherto.

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[172] *Galileo. Dialogue Concerning the Two Chief World Systems.* I. Pg. 37-38

Pontifex Urban VIII: I rather think science, as you speak of it, to be a decadent and watered down conglomerate that borrows from each, or at least many, of the forms or fields of knowledge. Such is my impression when I read the phrase ‘as to science itself, it can only improve’ in the same lines with ‘worry not about the ruin of philosophy’ and ‘save your concern for certain philosophers’.
Galileo: How, then, are we to resolve this problem?

Simplicius of Cilicia: Pontifex, I wish to describe the point at which this problem is hinges, if I may.
Pontifex Urban VIII: That would be helpful, Simplicius, as we seem to be at a standstill in disagreement.
Simplicius of Cilicia: As you and I are at a loss about what Galileo means by ‘science’, either about the topic of content or the bounds, we are unable as yet to make an evaluation. As Plato elegantly illustrated in the *Sophist*— “for as yet, you and I have nothing in common about him [the sophist] but the name; but as to the thing to which we give the name, we may perhaps each have a conception of it in our own minds; however, we ought always in every instance to come to agreement about the thing itself by argument rather than about the mere name without argument.”[173]
Pontifex Urban VIII: That seems to be precisely the predicament we are in. For, it is altogether unclear the definition of what they call ‘science’, and what is the content and domain of his ‘two new sciences’, and until we reach an agreement about that, our argument

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[173] *Plato. Sophist.* 218c

will be fruitless and sterile, and no evaluation will be possible. This is undoubtably the case, since they profess to be involved in something different from natural philosophy, or physics, and different from mechanics, and they are inventors of machines and instruments, among partaking in other divergent activities as well.

Galileo: Then are we to embark on the inquiry you suggest?

Pontifex Urban VIII: I'd rather not lose track of the end we primarily require by taking up a pursuit that is wrought with unclarity. I wish, rather, to continue with the investigation of 'science' in the terms with which I originally distinguished their movement from that of the Renaissance intellectuals of the last two centuries. For, we might not require a clear definition of your process of 'science' to discern the differences between that and the *sciens* of the Renaissance which we are familiar with, although Simplicius here might want to correct me, and I wish to avoid that dispute.

Galileo: Then I will comply to the course of the argument in that direction.

Pontifex Urban VIII: The impulse of the intellectuals before your scientific movement was towards recovering lost knowledge from antiquity, is that right?

Galileo: Yes

Pontifex Urban VIII: And did they not revive the Latin language to the standard of classical Roman antiquity, to purge the inadequacies of medieval forms and styles that had accrued upon that language? And did they not conduct themselves in the same manner regarding the Greek language, which had been unknown to western Europeans for seven hundred years, educating

themselves and others under the standard of classical Attic Greek?
Galileo: That is historically true.
Pontifex Urban VIII: They also composed literary works in classical Latin, after reviving the knowledge of that language?
Galileo: They did
Pontifex Urban VIII: Yet you compose your works in a regional dialect, when the learned class of intellectuals converse in classical Latin. Do you not?
Galileo: I compose my works in a regional dialect, yes, in Italian.
Pontifex Urban VIII: Then who is your intended audience? It cannot be the intellectual class, who write and read works in Latin, which aim at the persuasion of learned men.
Galileo: I would rather not restrict myself to the scholastic group.
Pontifex Urban VIII: Well, in any case, the ‘scientific’ movement you are a part of differs from the Renaissance movement in that respect, that the Renaissance intellectuals strive towards recovering and preserving classical Latin forms and styles, while you disregard the use of Latin as a whole and write in a regional dialect for all intents and purposes irrelevant to scholars.
Galileo: Some ‘scientists’ have written in Latin, however. As a whole, we attempt to distance ourselves from the scholastic philosophers and academicians, and for some of us, a regional dialect is a ready means towards that end.
Pontifex Urban VIII: I can only presume that you intend to persuade the masses of people in various

regions against the intellectual class, or else you would publish in Latin.

Galileo: Not with ill intent, but to enlighten them. And as I said, I would not be a part of the scholastic circles anyways.

Pontifex Urban VIII: I wonder, Galileo, about the difference in disposition between you and your father, Vincenzo Galilei. I am aware that he wanted to restore the forms of ancient Greek music in theory, ideal, and practice, and that he was a part of Camerata de' Bardi, or the Florentine Camerata, where there was a revival of the classical Greek dramatic style in music.

Galileo: He was

Pontifex Urban VIII: Obviously, then, he would take no notice of newly invented instruments, whereas you are fascinated by novel inventions of instruments in your field, and contend against the ancients in many respects.

Galileo: The case is different with music and the arts, and science, Pontifex.

Pontifex Urban VIII: I can only say that you and the rest of your scientific kinsmen are difficult to discern, for you seem to sprout up like weeds, without cultivation and without a previous generation of your craft to either instruct you or inspire you. There is something else, however, that I am concerned about, which you mentioned in the *Dialogue Concerning the Two Chief World Systems*.

Galileo: What is that?

Pontifex Urban VIII: You make a statement that expresses nihilism as regards to the humanities, ethics, politics, and law, in contrast to the possibility of truth which you say is reserved for the natural sciences. I am deeply concerned that your comrades in the endeavor of ‘science’ hold the same opinion that excludes truth and falsehood from ethics, law, politics, and the humanities in general. You say—

“If what we are discussing were a point of law or of the humanities, in which neither true nor false exists, one might trust in subtlety of mind and readiness of tongue and in the greater experience of the writers, and expect him who excelled in those things to make his reasoning most plausible, and one might judge it to be the best. But in the natural sciences, whose conclusions are true and necessary and have nothing to do with human will one must take care not to place oneself in the defense of error; for here a thousand Demostheneses and a thousand Aristotles would be left in the lurch by every mediocre wit who happened to hit upon the truth for himself.”[174]

Galileo: The methods of experiment and, also, demonstration are not applicable to the humanities, law, politics, or ethics. That is my view.
Pontifex Urban VIII: Yet syllogistic reasoning is used about those things, both in the senate and in law courts, and in ecclesiastical circles. And they are trained in that skill alongside rhetoric to attain proficiency and excellence in those fields. Would you then also suppose grammar to be without truth and falsity; and history, would you dare to say that there is no truth or falsity about historical events?

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[174] *Gaileo. Dialogue Concerning the Two chief World Systems.* I. Pg. 53, 54

Galileo: I would exclude those from the truth and falsity that can be attained in the physical sciences. History and the events therein, even if containing truth or falsity, cannot be investigated and discerned with the same degree of certainty that is possible for physics, mechanics, astronomy, and the like. As for grammar, I consider that to be entirely conventional, and containing truth and falsity only in terms of what is agreed upon by the group that uses the language. The rest of the fields you mentioned, I consider under the sway and domain of rhetoric, which, unconcerned with truth can persuade for the sake of advantage and gain.

Pontifex Urban VIII: Is that also the position held by your affiliates?

Galileo: Largely, yes.

Pontifex Urban VIII: No one would bother you, Galileo, if you were wholly concerned with 'scientific' investigations and even if you were rhetorically persuading people in your city and region about those matters, however, I should say, your astronomical theories converge with theology and have affects therein. And I should say what I mean by theology. When you are accused of contradicting the 'scriptures', you are not merely up against the bible. The church considers as 'scriptures' the writings of the early church fathers and the sources they drew from, much of which you are wholly unacquainted with. Astronomy naturally converges on theology, and a "Copernican revolution" inevitably results in a revolution of what is thought to be aeternal and divine. You make radical claims in terms of what is aeternal and what is generable and corruptible, from your astronomical theories. Besides that, however, which would still probably render you obscure from the perspective of the church, these claims you make about there being no truth and falsity about the humanities and law indicate that you are set against all authority and intended to tear down the structures of tradition.

Simplicius of Cilicia: If you think, Pontifex, that we ought to continue with this train of thought, out of importance of the subject, I am willing to be at your assistance in the argument. I think this point in the argument can receive additional depth.
Pontifex Urban VIII: I would be more that glad if you would come to my aid in this part of the discussion.

Simplicius of Cilicia: You say, Galileo, that there is no truth and falsehood about the humanities, law, and politics?
Galileo: I made that statement, yes.
Simplicius of Cilicia: Then do you also say that there is no truth and falsity about the better and worse?
Galileo: In terms of what?
Simplicius of Cilicia: In terms of a course of action to be taken.
Galileo: No, I don't think there is truth and falsity about those kinds of things.
Simplicius of Cilicia: Then if a state is disposed to decide about whether to declare and take actions of war against another state or whether to remain neutral, do you not think there is a better and worse decision out of the possible course of events in that matter?
Galileo: I suppose so.
Simplicius of Cilicia: Or whether to prepare for defense against a large-scale invasion or not to, is

there in that decision a better and a worse course of events?

Galileo: Yes, I suppose.

Simplicius of Cilicia: And to make and alliance with another state or not, is the case the same, and is there a better and worse course of action in that decision?

Galileo: Yes, it seems so.

Simplicius of Cilicia: And by better, you mean ‘truly’ better, and by worse, ‘truly worse’? Or could those terms even be applied if they weren’t meant to be truly such.

Galileo: Can you explain?

Simplicius of Cilicia: If one course of action is better and another is worse, for a state or for a household or an individual, and you agree about that much, then there would have to be truth and falsehood regarding the decision of which course of action is better, would there not? Supposing that two sides dispute about which of two courses of action are better for a state, and one of the two courses of action is better, and one is worse, either, say, to go to war or remain at peace, then there would have to be truth and falsity about which of the courses of action is better, would there not?

Galileo: In those terms, yes. But I consider that to fall under the domain of rhetoric and persuasion, not science.

Simplicius of Cilicia: Well, let us take a step back and examine history, for that is not a physical science, and you said at first that truth and falsity only apply to the physical sciences.

Galileo: Go on

Simplicius of Cilicia: Observe this passage from Plato’s *Laws*, and see if you agree. He writes—

“Athenian: Very well then: what precaution ought the legislator to have taken at that time in his enactments, to guard against the growth of this disorder? Verily, to perceive that now requires no great sagacity, nor is it a hard thing to declare; but the man who foresaw it in those days—if it could possibly have been foreseen—would have been a wiser man than we.
Megillus: To what are you alluding?
Athenian: If one looks at what has happened, Megillus, among you Lacedaemonians, it is easy to perceive, and after perceiving to state, what ought to have been done at that time.”[175]

And in a following passage the same point is made—“That we should understand this, after the occurrence, is—as I said before—no great mark of sagacity, since it is by no means difficult to draw an inference from an example in the past; but if, at the time, there had been anyone who foresaw the result and was able to moderate the ruling powers and unify them,—such a man would have preserved all the grand designs then formed, and no Persian or other armament would ever have set out against Greece, or held us in contempt as a people of small account.”[176]

Galileo: I agree that it is easier to comprehend the right or wrong course of action taken in the past than to foresee the right course of action in the present for the future.

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[175] *Plato. Laws.* III. 691b

[176] *Plato. Laws.* III. 692b

Simplicius of Cilicia: Then truth and falsity are applicable to history, and easily discoverable there, are they not?
Galileo: They are.
Simplicius of Cilicia: And is there not a sort of kinship between history and politics, as history pertains largely to the events of states as a whole, which is what politics is set over?
Galileo: There is.
Simplicius of Cilicia: And you agree that there is a better and worse course of action that can be taken in regard to some decision, in political affairs?
Galileo: I agreed to that, yes.
Simplicius of Cilicia: And when the decision is about which course of action is the better, there is a true and a false answer to which is better?
Galileo: Yes
Simplicius of Cilicia: Can the art of rhetoric discover which course of action is better, or is rhetoric only the mode by which others are persuaded about which course of action to take, in that context?
Galileo: Rhetoric, I presume, is only the mode of persuasion, not of inquiry and discovery.
Simplicius of Cilicia: Then politics as an art and science doesn't fall completely under the domain of rhetoric, as you suggested, but rhetoric is employed in politics.
Galileo: That seems right.
Simplicius of Cilicia: And history, I should add, is supplementary to politics, as parallels can be drawn from prior events which had similar outcomes to the future outcomes of events that statesmen debate about. Do you agree with that?

Galileo: Yes, and I agree that the truth and falsity of past events, like you said, is easier to ascertain than future outcomes of present events.
Simplicius of Cilicia: For the sake of this argument, we have not much else to discuss about that topic. You also mentioned law as something about which there is no truth and falsity.
Galileo: Yes
Simplicius of Cilicia: About that, we need not use the better and worse as a means to reach truth and falsity, as we had to in the previous part of the argument. Answer if you would say that lawcourts decide whether someone was wronged or not.
Galileo: They do.
Simplicius of Cilicia: Can you possibly hold the position that it is entirely a matter of persuasion whether or not someone was wronged, and that there is no truth or falsity about whether or not they were really wronged, but that lawyers and experts in law make rhetorical performances like acts of drama about an event that neither did nor didn't really happen?
Galileo: I suppose there is truth and falsity about those things too. However, as with politics and the humanities, the discovery of the truth is not ascertained with the same certainty and validity as are the physical sciences.
Simplicius of Cilicia: Well, are the physical sciences, as you call them, not derived from the mathematical sciences?
Galileo: In what way?
Simplicius of Cilicia: Is harmonics, for example, not derived from and dependent upon arithmetic, or could you conceive of harmonics without ratios of numeric proportion?

Galileo: Harmonics is dependent upon arithmetic, yes.
Simplicius of Cilicia: And is astronomy not derived from and dependent upon geometry, or could you conceive of astronomy without circular and straight lines, and of figures bounded by those?
Galileo: Astronomy is dependent upon and derived from geometry, yes. However, the 'science' that is under development by Copernicus and myself, and many others, makes a great deal less use of the mathematical disciplines in astronomical investigations.
Simplicius of Cilicia: Then, if the physical sciences are derivative from the mathematical, and don't in their own right have the criterion of *sciens*, then what right have you to assume the humanities to be excluded from knowledge, and from truth and falsity?
Galileo: I can say that there is a greater gap to bridge between mathematics and the humanities than between mathematics and the physical sciences.
Simplicius of Cilicia: And yet you admit to bypassing mathematical demonstration at any chance observation and experimentation lends you.
Galileo: An inquiry into that point would bring us to an understanding of the meaning of 'science' as we use the word.
Simplicius of Cilicia: And we would be weary to continue after that. I hand the discussion, Pontifex, back over to you.

Pontifex Urban VIII: I have a further point to make regarding the distinction between the forms of knowledge and art rediscovered in the Renaissance and the nuanced science that is the matter of speculation in this inquisition. From what I have read

and heard said about the new science of today, and contrasting that with the natural philosophy and physics of the ancients, I am apt to think that the difference lays in value. That ancient physics held different values than the science of Copernicus and you, Galileo, and that there is some significant divide along those lines that draws you away from them methodologically.
Galileo: What makes you say that?
Pontifex Urban VIII: Quotes like this, which I took from your *Dialogue Concerning the Two Chief World Systems*—

"I declare that we do have in our age new events and observations such that if Aristotle were now alive, I have no doubt he would change his opinion. This is easily inferred from his own manner of philosophizing, for when he writes of considering the heavens inalterable, etc., because no new thing is seen to be generated there or any old one dissolved, he seems implicitly to let us understand that if he had seen any such event, he would have reversed his opinion, and properly preferred the sensible experience to natural reason."[177]

When you say that Aristotle would have preferred sensible experience to reason, and would change his opinion based on observations, I not only think that you are unacquainted with the Philosopher, but that you, as I said, reverse the values he held. I know not if you say such things from misunderstanding and a misreading of the text, or if you purposefully drag him along in the direction you take everything. In many other places you say that Aristotle would change his opinion if he were alive today on the basis of an experiment you made that. You seem to know not that he had access to thousands of years of records kept by Egyptians about astronomical 'observations', as well as calendrical records about astronomical phenomena. I think he would laugh at your menial experiments, and think they would show him nothing at all, and that he would have the same response about your inventions of instruments to obtain those observations. I cannot quite express the point I am trying to make so I will have to ask Simplicius for assistance.

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[177] *Galileo. Dialogue Concerning the Two Chief World Systems*. I. Pg. 50

Simplicius of Cilicia: I would be glad to explain the point you have made. There is a common misunderstanding of the Philosopher that is prevalent among scholastic Peripatetics as well. The origin of the misunderstanding is an attempt to distinguish the philosophy of Aristotle from that of Plato. Remember, first, that Aristotle was a student and disciple of Plato for twenty years, and that he went to Athens and entered the Academy at the young age of seventeen, and only left the Academy when the position of scholarch was passed to Plato's nephew, Speusippus. There is an old story about Plato making a comment to his students at the Academy to the effect that, truth is what is thought by the intellect of Aristotle, perhaps in exaggerated praise of his best student, but indicating to us, in any case, that they held each other in high esteem. By attempting to distinguish the two, philosophers since their time have forced a diametrical opposition between them, regarding epistemology especially. But to continue with the problem—

What you said, Pontifex, is accurate. Aristotle would not value experimentation and observation so much as to weigh an entire problem, such as these grave astronomical difficulties, on a mere experiment, when they are not even matters of direct visual perception—that is, the arrangement of the cycles of the celestial bodies in relation to each other, even if the objects themselves are visible, is not discernable by a single vision of any of them at any one time, but require a collection of observations that serve as material to be reasoned about. Whether the earth moves around the sun or the sun around the earth, for example, isn't something that can be observed in a single encompassing perception—but many observations of the position of the sun at different times while in different positions have to be collected into a coherent theory by reason and argumentation.

In fact, both of those theories attempt to account for the phenomena, which are plentiful and not reducible to a single observation or experiment, and, like I said, require sorting out 'observations' with reason and argument. Your own heliocentric theory goes against the observable phenomena of the sun and moon and other celestial bodies rising and setting in cyclical rotations around the earth; for, no one can deny that they appear to 'rise' and 'set' as if circling around the earth. Nor could you ever think it to be possible to observe the earth moving around the sun in one encompassing perception. These problems are matters to be weighed out with reason and argument, and, as I said, cannot be reduced to a single observation or a makeshift experiment with questionable devices. Aristotle would, then, absolutely not change his conviction about the stationary or mobile nature of the earth or the sun due to an experiment you showed him, because the earth's rotation around the sun or the sun's rotation around the earth cannot be encapsulated in a single visual perception.

The difference between your theories, I think, comes down to a difference in values and in methodology, like the Pontifex said, and there is a vast disconnect between the different sides of the argument when there is no common ground about methodology. Regarding your interpretation of Aristotle, what would someone who, as you say, 'preferred sensible experience to reason', have to do with writing the *Organon*, the complete arrangement of every conceivable valid form of logical proof and demonstration. None of these sorts of theories would be open for contention if they were about things that could be plainly 'observed' in a single visual perception. They require reasoning and arguing through a great multitude of observations, which serve, if at all, as matter to be formed into something cognizable. Thus in my *Commentary on Aristotle's De Caelo*, I wrote that—
"Plato posed the question to students at his Academy—by what uniform and orderly motions can the apparent motions of the planets be accounted for? Plato proposed that the seemingly chaotic wandering motions of the planets could be explained by the combinations of circular motions centered around the spherical earth."

A theory about the arrangement of the cosmos, then, obviously requires further reasoning about a variety of observations of the positions of the sun and other luminaries at different times, and so, the arrangement of the cosmos cannot be observed in a single encompassing perception, and nor can the reasoning about many observations at different times come down to any single observation, experiment, or perception.

Pontifex Urban VIII: I want to say something else regarding that, about, specifically, the Copernican scientists overvalue of novel inventions, along with observation and experiment, that sets them apart from the ancients and from everyone before them in terms of what they value, and in terms of methodology. I should quote another passage from your *Dialogue Concerning the Two Chief World Systems*, to reiterate your interpretation of Aristotle, which Simplicius, here, just refuted.

"To all these things we have the most suitable answers, which I omit for the present in order that we may come to the particular reasons and sensible experiments which ought to be finally preferred, as Aristotle well says, above anything that can be supplied by human argument."

When you attribute to Aristotle the position that "sensible experiments ought to be finally preferred above anything that can be supplied by human argument" you reveal, in your misinterpretation of the Philosopher, that you possess different values, which you impose on your reading of him, and that you differ inconsolably from him in terms of epistemology. For, you impose on Aristotle your own position, that the final criterion of a problem or dispute depends upon sensible experiments in preference to 'human argument'. This, I think, is a difference in value, although intertwined by context with epistemology.

You reveal, by statements like that, which are plentiful in your writings, that you are unique and different, from both the ancients and the intellectuals of the last two centuries that recovered and emulated the knowledge rediscovered again from antiquity, in your optimism about novel inventions and 'scientific' observations made thereby. Your position appears to me as diametrically opposed to the Renaissance scholars in your impulse towards novelty, invention (of instruments of science), the future, and progress; whereas they valued rediscovery and the conservation of antiquity, both intellectually and aesthetically, in the *renaistre* of ancient forms of knowledge and artistic beauty: that is, in architecture, sculpture, music, forms of government and societal arrangement, and, of course, education.

Galileo: The new science differs in that respect, yes, although while restricting itself to the physical sciences.
Pontifex Urban VIII: But that is only a consequential result of your overarching evaluative claim, that the material sciences are the only habitation of truth and falsity, and that perception is the chief means and criterion of obtaining knowledge, and that, meanwhile, 'human reason' fails to discern or obtain knowledge, both in physics and in metaphysics, as well as in ethics, law, politics, and the *studia humanitatis* in

general—that is, grammar, rhetoric, poetry, history, and moral philosophy—these *humanitas disciplinis* being derived from a rearrangement of the *trivium* portion of the *septem artes liberales* of classical Rome, which the scholars of the *renascens* rediscovered and erected as a cultural ideal and path towards the development worthy of a free person. And, although you don't possess the *authoritas* to deconstruct the overarching structure of those noble pursuits, aside from your persuasive appeal about matters of physics and astronomy, you indirectly turn people away from the *humanitas disciplinis*, and, I recon, your intention would be their complete deconstruction if that decision were within your power.

So, Galileo, the investigation of your doctrines by Cardinal Bellarmine and Francesco Ingoli and your subsequent trial and judgement should be understood in light of your evaluation of truth and falsity as wholly restricted to the physical sciences and excluded from the noble pursuits of the *studia humanitatis*, alongside your indirectly, or perhaps semi-directly, meddling with theological and metaphysical doctrines by way of your astronomical claims.

You were ordered, if you recall, "to abstain completely from teaching or defending this doctrine and opinion or from discussing it... to abandon completely... the opinion that the sun stands still at the center of the world and the earth moves, and henceforth not to hold, teach, or defend it in any way whatever, either orally or in writing."

Now, I wish to hear a discussion between you and Simplicius about ‘falling bodies’, because you have gained a widespread reputation thereby, more so, I believe, than for any astronomical discoveries or for inventions of scientific instruments like your telescope; and again, for contradicting and appearing to overthrow Aristotle.

Simplicius of Cilicia: I refrained from bringing up this contention, Pontifex, because the rate of speed at which heavy bodies fall is never a primary concern of the inquiries conducted by the Philosopher. That is mentioned by him not even as a premise of an argument about any topic—and certainly not as a targeted conclusion—but, rather, as a sort of side note alongside something else that is said about weight, lightness, motion, and the elemental bodies. In my opinion, Galileo used his apparent overthrow of an insignificant footnote of Aristotle to catapult his reputation and thereby grant recognition to his other theories. Neither do I think that Aristotle himself would think it worthy of himself to contend about such trifling trivialities. Such distinguishes the menial topics and targets of investigation of these ‘new scientists’ from that of natural philosophy and ancient physics. Commentators on Aristotle’s *Physica*, *De Caelo,* and *On Generation and Corruption* don’t even expand on or even mention such niceties and particulars that are irrelevant in the general scope of his arguments—and the commentators, including myself, explain the embedded significance of almost every detail in those texts, which, I should remind you, are his lecture notes, and that his dialogues and works meant for publication have since been lost. Since, however, Galileo, has derived widespread recognition for overthrowing these particulars in the lecture notes of Aristotle, I am desirous to defend the philosopher, who, I think, was not overthrown in these matters either, although they, like I said, were for the most part irrelevant to his arguments, and mentioned alongside the immediate premises and conclusions relevant to the topic at hand.

Pontifex Urban VIII: What, then, would you like to say in defense of Aristotle about this contention brought about by Galileo that has won him widespread recognition.
Simplicius of Cilicia: His arguments can be picked apart dialectically. However, he also, as in other places and about other topics, misrepresents the arguments of the Philosopher. So, there is a difficulty in approaching those problems at once.
Pontifex Urban VIII: I should say, the issue is not altogether clear to me.
Simplicius of Cilicia: In some cases, Pontifex, he somewhat agrees with our conclusions, but adding complexities, compounds variables so that he might be thought to say something novel and not before claimed. I will provide a quotation from his *Discourses and Mathematical Demonstrations Relating to the Two New Sciences*.

“ The experiment made to ascertain whether two bodies, differing greatly in weight will fall from a given height with the same speed offers some difficulty; because, if the height is considerable, the retarding effect of the medium, which must be penetrated and thrust aside by the falling body, will be greater in the case of the small momentum of the very light body than in the case of the great force of the heavy body; so that, in a long distance, the light body will be left behind; if the height be small, one may well doubt whether there is any difference; and if there be a difference it will be inappreciable."[178]

From this passage, it is clear that he admits and consents to the Peripatetic doctrine that heavier bodies really fall at a greater speed than lighter bodies, all else aside. However, in what follows he argues for an additional variable alongside weight, that is, surface area, that in conjunction with 'air resistance' reduces the speed of falling bodies. This complicates the issue more so than contradicts the position held by Aristotle.
Pontifex Urban VII: So, Galileo doesn't say that heavy bodies don't fall faster than bodies of less weight?
Simplicius of Cilicia: Well, as I said the issue is complicated, and he makes that claim, however, with the peculiar qualification that heavy bodies wouldn't fall at a greater speed *if they were to fall in a void, without air resistance.*
Pontifex Urban VIII: I know not what to make of that.
Simplicius of Cilicia: Neither do I, as the physical speculation has to do with heavy bodies falling in and through air, and not any other medium. The complexities that arise in his investigation of the topic are, as I said, worth ignoring or disposing of, as a

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[178] *Galileo. Discourses and Mathematical Demonstrations Relating to the Two New Sciences. I. Pg. 84*

Peripatetic defense would be futile and require an effort that exceeds the gain.

Pontifex Urban VIII: Nonetheless, Galileo's reputation seems to be magnified by the dispute surrounding this topic.

Simplicius of Cilicia: That is right, however, Aristotle's reputation has nothing to do with such inconveniences.

Pontifex Urban VIII: Yet, *per accidens*, Galileo's appearing to champion the Philosopher about this seems to have elevated the credibility of his refutations of Aristotle regarding the topics of astronomy and physics in general.

Simplicius of Cilicia: You are right, however, from a philosophical perspective no harm has been thereby affected upon the Peripatetic doctrines. Among the many, of course, persuasion has ensued from such an irrelevant and accidental appearance of a dispute.

Pontifex Urban VIII: I still think you should say more about the situation.

Simplicius of Cilicia: Then I might refer to another passage of his from the same book. You will see that he consents to the Peripatetic position, with the addition of peculiar additions.

"if Simplicius is satisfied to understand and admit that the gravity inherent [interna gravitas] in various falling bodies has nothing to do with the difference of speed observed among them, and that all bodies, in so far as their speeds depend upon it, would move with the same velocity, pray tell us, Salviati, how you explain the appreciable and evident inequality of motion; please reply also to the objection urged by

Simplicius—an objection in which I concur—namely, that a cannonball falls more rapidly than a birdshot."

Here, Pontifex, it is clear that he admits that a cannonball falls more rapidly than a birdshot. He explains why and what cause he attributes that to in the following passage:

"The action of the medium in producing a greater retardation upon those bodies which have a less specific *gravitas*, that is weight, has already been explained by showing that they experience a diminution of weight."

Thus, he attributes the difference in speed observed among falling bodies of different weights to the medium through which they fall, not to the weight of the bodies themselves. After which, he later claims that, if the bodies of different weights were falling through a void without air resistance they would fall with the same speed. I assume he makes that leap to the exclusive causality of air resistance on surface area, without attributing a significance to weight, from the mutual causes of weight and the drag from surface area along air resistance. There is a subtility about mutually causative factors, and attributing the cause as a whole to one or the other of them, which, I think is the issue we face in this dilemma.

Pontifex Urban VIII: Then you say that the dilemma comes down to a question of logical validity?
Simplicius of Cilicia: That is how the problem unfolds upon my own speculation. I would like, however, to pose questions to Galileo.

Pontifex Urban VIII: You may proceed with the interrogation.

Simplicius of Cilicia: Then, Galileo, is not the force required to lift a heavy body equal to the force with which it falls?
Galileo: I believe it to be exactly so, and it is for this reason that two equal weights in a balance are seen to remain steady and in equilibrium, the heaviness of one weight resisting being raised by the heaviness with which the other, pressing down, seeks to raise it.[179]
Simplicius of Cilicia: And that—the force required to lift a body—is equal to its weight?
Galileo: Yes
Simplicius of Cilicia: Then forget about the speed. We agree, do we not, that the force with which a body falls is equal to the force required to lift that body?
Galileo: We agree about that.
Simplicius of Cilicia: And those are counterforces—the force with which the body falls, and the force required to lift or transport that body?
Galileo: Yes
Simplicius of Cilicia: Then, you would also say, would you not, that the force required to lift a given body is the counterforce of its weight?
Galileo: Yes
Simplicius of Cilicia: And we said that the force required to lift a given body is the counterforce of the force with which that body falls?
Galileo: We said so.

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[179] *Galileo. Dialogue Concerning the Two Chief World Systems*. II. Pg. 213, 214

Simplicius of Cilicia: Then, can a thing have more than one contrary, or is their only one contrary available to any given thing?
Galileo: A thing can only have one contrary.
Simplicius of Cilicia: And the counterforce is the contrary of the force in question?
Galileo: Yes
Simplicius of Cilicia: Then, if the force required to lift a given body is the counterforce to both the force with which that body falls, and to the weight of that body, and a thing can only have one contrary, and the counterforce is the contrary of the force in question, then are not the weight and the force with which a body falls one and the same?
Galileo: Yes, they are.
Simplicius of Cilicia: Now, wind resistance, or air resistance, is, as you say, a sort of counterforce working against the speed of falling bodies in proportion to their surface area, whose declination is decelerated by the medium through which they fall. Is that right?
Galileo: That is right.
Simplicius of Cilicia: And as a counterforce, the air resistance of the medium through which heavy bodies fall must be a resistance against the force of the falling bodies?
Galileo: That would seem right.
Simplicius of Cilicia: And the force with which bodies fall is the same as their weight, we said?
Galileo: We said that.
Simplicius of Cilicia: And we said the air resistance of the medium through which they fall resists as a counterforce both their speed and the force of their fall, is that right?

Galileo: Yes
Simplicius of Cilicia: Then, you must say that these—the speed and the force with which heavy bodies fall—is the same or related as part to whole. I don't see any other option for you.
Galileo: I say, then, that they are related as part to whole. For, I claim that the speed of falling bodies is determined by both the weight and the surface area, and so, the ratio between the weight and surface area of the body, according to my theory, culminate in the speed of the falling body. I say that weight may be equivalent and result in the force of a falling body, but that speed is determined by both weight and surface area.
Simplicius of Cilicia: But the weight, according to your colleagues, is comprised of both density and volume. Is it not?
Galileo: It is.
Simplicius of Cilicia: And the volume is in proportion to the surface area, so that, an increase in volume increases the surface area, and a decrease in volume decreases the surface area. Would you not say that?
Galileo: I suppose I would.
Simplicius of Cilicia: You said, did you not, that "the volumes stand in sesquialteral ratio to their surfaces,"[180] so that they increase and decrease according to the proportion of 3:2?
Galileo: I said that.

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[180] *Galileo. Discourses and Mathematical Demonstrations Relating to the Two New Sciences*. I. Pg. 90

Simplicius of Cilicia: Then volume and surface area are mutually dependent terms?
Galileo: Yes
Simplicius of Cilicia: And if we increase the volume of a given body, while the density remains the same, does not the weight increase?
Galileo: It does.
Simplicius of Cilicia: Then, as we agreed, the density and volume comprise the weight of a body?
Galileo: Yes
Simplicius of Cilicia: And an increase or decrease in volume results in an increase or decrease in surface area, as directly proportional?
Galileo: Yes
Simplicius of Cilicia: And contrariwise, and increase or decrease in surface area must be accompanied by an increase or decrease in volume?
Galileo: That is true.
Simplicius of Cilicia: Then if volume is a mutual cause of weight alongside density, according to your conception, and volume is mutually dependent with surface area, is not surface area also a factor in weight? Or, if the density of a body remains constant, could an increase or decrease in surface area, alongside affecting an increase or decrease in volume, not also affect an increase or decrease in weight, all else aside?
Galileo: That seems right.
Simplicius of Cilicia: But you said the speed of falling bodies is determined by both weight and surface area and not just weight alone. Did you not?
Galileo: I did.
Simplicius of Cilicia: Yet, according to the argument, surface area is a causal factor in weight, as an increase

of surface area increases the volume by a sesquialteral ratio, and an increase in volume, given that the density is constant and unchanged, increases the weight also. Is that right?

Galileo: That follows, according to the argument.

Simplicius of Cilicia: Then weight, as the whole comprising both density and volume, the latter of which is mutually dependent with surface area, must, as the whole comprised of the others, be the sole cause of what you say is caused by both the whole and one of its parts. I don't see any way around that.

Galileo: Yes. However, a difference in shape, the other variables remaining constant, would still, according to my theory, affect the speed of fall.

Simplicius of Cilicia: That is enough for me, however, for Aristotle himself says that shape affects the fall of bodies. For he says— "The shape of bodies will not account for their moving upward or downward in general, though it will account for their moving faster or slower. The reasons for this are not difficult to see. For the problem thus raised is why a flat piece of iron or lead floats upon water, while smaller and less heavy things, so long as they are round and long, like a needle, for instance, sink down; and sometimes a thing floats because it is small, as with gold dust and the various earthy and dusty materials which throng the air."[181]

Galileo: Then our positions are not so much as diametrically opposed to each other.

Simplicius of Cilicia: Not in that respect. And not in this either—you say that all heavy bodies fall, or would fall given that they were in a vacuum or void— with equal speed, regardless of their weights. Although Aristotle says no such thing, and denies the existence of a void, in a sense, he admits that all earthen bodies are absolutely heavy and all bodies of fire are absolutely light, in contrast with bodies that have a share of each. That is, in one sense, in alignment with your claim that all earthen bodies fall at the same speed, since he grants all earthen bodies absolute weight in comparison to the other elements, since earthen bodies sink to the bottom of any medium that they are in. He, however, as you know, attributes their difference in speed of descent to their difference in weight. I will provide the quotation for convenience— "We may distinguish the absolutely heavy, as that which sinks to the bottom of all things, from the absolutely light, which rises to the surface of all things. I use the term 'absolutely' with reference to the genus and to those bodies which do not combine lightness and heaviness. It is apparent, I mean, that fire, in whatever quantity, so long as there is no external obstacle, moves upward, and earth downward; and if the quantity is increased, the movement is the same, though swifter. But the heaviness and lightness of bodies which combine these qualities is different from this, since while they rise to the surface of some bodies they sink to the bottom of others. Such are air and water."

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[181] *Aristotle. De Caelo.* IV. 6. 313a, 14- 21

Such, then, Galileo, are the reasons why I didn't initially attempt to address this disagreement between the Peripatetic position and your own about this topic, especially with regard to the confusion about mutual causal factors and claims about one or the other of their exclusive causality, but also with regard to the complicated task of identifying, distinguishing, and resolving your view with ours; and, finally, because Aristotle does not place great weight on these concerns, but references the points that you have attempted to disprove by the way and as supplementary at best, neither, I say, as premises, nor as conclusions of significant arguments of his.

Pontifex Urban VIII: That is enough, I think, about that issue. And this discussion can be concluded there, without any final address, for, we are left now to weigh out amongst ourselves the various positions that have been represented and argued for and against in the preceding discourse.

EPILOGUE CONCERNING THE CALENDRICAL MONTHS IN RELATION TO THE ZODIACAL MONTHS

THEORY THAT THE CALENDRICAL MONTHS ARE FIXED TO THE SEASONS, AND THAT THE SUN'S POSITION IN ANY GIVEN ZODIACAL SIGN IS IN VARIATION WITH BOTH THE CALENDRICAL MONTHS AND THE SEASON, DUE TO EQUINOCTIAL PROCESSION—

The problem at hand is the variance of the sun's position in the zodiac in relation to the season (spring, summer, fall, winter) of the year, or the change of the equinoctial sign every 1,800 or 2,160 years. Forever astronomers have been making adjustments to account for that slow but continuous difference over time of what sign the sun is in at the time of the spring equinox, or, for that matter, the solstices and autumnal equinox as well. Gradually the position of the sun at the vernal (spring) equinox shifts from Ares to Pisces to Aquarius, and with that shift indefinitude seeps in.

For, in one age people are counting the beginning of the year with the onset of the sign that the equinox happens to be in then, but as the sun reaches its equinoctial point in the following sign (at a rate of sixty or seventy-two years per one degree) eventually they count the beginning of the year a month late, and the equinox surprisingly arrives before the sun reaches the sign that it had reached the equinoctial point according to their previous account.

Thus, there is an indefinite problem of when to shift the charts to make up for that phenomenon. The seasons and sun's position along the zodiac change relative to each other; for the change of seasons and the arrival of equal time of day and night (usually corresponding with March 21st, 22nd, or 23rd) isn't on its own either trackable or predictable without the sign of the zodiac to mark its arrival, and neither is the zodiacal position of the sun without the seasons of the year significant of an annual cycle, since the seasons comprise the annual cycle.

Thus, the fixed stars of the zodiac are used to determine when the seasonal equinox occurs or will occur and the seasons are used to affirm the cyclical return of the Sun, as they show an unmistakable signification of that cause of such effects in their seasons, i.e. the position of the Sun.

The fixed stars are rightfully the measure of the positions of the lower bodies. I concede the fact that the zodiac are among the fixed stars, however their heliacal rising isn't as prominent as the brightest stars that aren't in the zodiac, which fall north or south of the zodiac belt, and that have been used for agriculture and navigation for the ease of sighting them due to their brightness, like Canis Major in the southern sky, Arcturus in the northern sky, and the Pleaides in the zodiac constellation Taurus, and Spica at the hip of Virgo.

And I assume that the calendar has been attempted to be fixed in some manner to make up for the variation of the time of season that the Sun occupies certain zodiac signs.

There are two ways to track the beginning of the year. Either the beginning of the year is the seasonal equinox or solstice which eventually changes signs, or the heliacal rising of a fixed star attached to some degree of some sign that eventually won't take place in the same season.

It is a wonder that instead of having calendrical months we don't use each zodiac sign as the beginning and end of each month, and call the month by the name of that 'animal'. Whatever the case, I find it useful that there is a third measure, developed as the calendrical month, separate from both the twelve zodiacal months and (perhaps) from the seasons, which may be allowed to vary in relation to each other.

The task is to determine if the calendrical months are somehow fixed, and if the zodiacal months and seasons vary in relation to each other, or if the calendrical months vary along with them, but add a third measure, if, especially, they aren’t tied to the seasons; or if they are tied to one or the other of the two measures mentioned that are at variance due to the gradual equinoctial cycle.

The most significant premise is that the calendrical months (i.e. 1st of January, 1st of February, etc.) don’t align and aren’t meant to align with the first degree of such and such zodiacal sign. Another significant premise is the unquestionable seasonal variance of the zodiacal signs slowly over time, and the probable or less obvious variance of the calendrical months in regard to one or the other of those two variables.

It is my intention to find an anchor in the calendrical months that is somehow ‘fixed’ to one or the other of the two other variables, either the seasons or the zodiacal signs; since those latter two are unquestionably at variance with each other.

Otherwise, there would be no use for a third measure that doesn’t align with the zodiac signs, with calendrical months interposed halfway through zodiacal months. As far as I know there were always calendrical names of months that differed from the zodiacal animals that make up the twelve signs, and may or may not have aligned with them as the first day of the month to the first degree of the sign. There is always the chance that adjustments due to equinoctial shift caused this, and there is also the chance that the calendrical months were interposed so as not to agree with the zodiacal months in order to make up for the seasonal change over time, i.e. which sign the sun inhabited during spring, summer, fall, or winter. There is also the possibility that the calendrical months, if at variance with the seasons in the same way the zodiacal months are, make possible the 'triangulation' of past dates that would be otherwise impossible, though they suffer the same indefinitude.

Or else, their interposition would only confuse our translation of past dates and create a sort of double-vision, where we sometimes have reference of calendrical months and sometimes of zodiacal month, and sometimes of seasons. Either way, the attempt to set the beginning of the year in calendrical months instead of seasonal points like the equinox or solstices and instead of the zodiac deserves speculation.

The primary example of the problem of variance between the zodiacal months and the seasons (without a third measure) is the progression of 'ages' from, say, Taurus to Ares, meaning at the time of spring, or the beginning of the warmer half of the year, or the vernal equinox, the Sun was in Taurus starting around 4000 b.c., and the Sun was in Ares starting around 1,800 or 1,600 b.c., and then again in Pisces during the spring equinox around 325 a.d. So that, if any civilization over that span of time placed the beginning of the year at the spring equinox, the Sun would discontinue to be in the same sign at the spring equinox; so much that, in the following equinoctial sign, Aquarius, which I consider as five degrees or at least three hundred years from now, Taurus, the above mentioned sign, would be the place the Sun inhabits during the summer solstice, a whole ninety degrees from when some people may have marked the beginning of the year during spring with the Sun’s inhabiting that sign. In the same way, if any civilization used, instead of one of those specific signs as marking the start of spring and the year, the spring equinox itself, regardless of the sign the Sun inhabited at that seasonal point, as the beginning of the year, they would eventually find that the Sun was in a different constellation during their supposed equinoctial new year. And the problem falls more so on future and later peoples that try to make sense of the timing of some event, who removed from ‘that age’ are at a loss about, say, the month of a certain festival, for example, and err when trying to duplicate the celebration of whatever they meant to imitate of the ancients. Perhaps if the event was meant to be celebrated in regard to the season, like some agricultural festival, they err by fixating on the sign they are told the celebration occurred before. Or, if the event was meant to celebrate a constellational figure, like Heracles or Orion, they err regarding the season that the festival was said to take place in, by only having reference to the season, say, if it occurred in mid-winter or summer, when those signs appear at different times of the year over the course of the ages.

There is reason to speculate that the calendrical months are even more indefinite, especially if that is all we have as a reference, however, like, for example, the first day of Hecatombion of the Attic calendar, which, without another reference, would be difficult to translate into the Gregorian calendar. However, there must be significance to the ancients assigning different names than the ‘animal signs’ and giving them numbers, in order to account for, first, the intercalation of days to months and the year, so that the whole revolves around to the same point, and, secondly, to, perhaps, fix the calendar to the seasons, when the zodiacal signs are bound to wander from their seasonal stations in regard to the year. Or else, they would have been likely to keep the names of the animals to avoid confusion, and not transpose a double system of months over and not set with the first day equivalent to the first degree of the sign they originated from.

This is meant as a speculation and should end in a theory, rather than begin with one that is meant to be proved. An example is the case with the Roman calendar in relation to the state of things today. They used the first day of March as the beginning of the year for the reason that they took that to align with the first degree of Ares, which was the sign that the Sun was in during the spring equinox. It is notable that rather than placing the year in the middle of Ares, which is probably where the equinox fell, they used the calendrical month, although it corresponded first day to first degree with the constellation Ares, to set the beginning of the year just before the equinox, and not tie the beginning of the annual cycle to the (quarter) seasonal point, which would be more determinate in regards to the seasons of the year. Rather they used the beginning of the Sun's position in the constellation Ares (at the first degree) and named the month March after Ares, who was famed to 'march'. Although the calendrical and zodiacal month corresponded, it is significant to the development of this theory that they didn't wait for the seasonal equinox as the start of the year, but set that at the first point the Sun entered the sign that (the middle of it) brought the beginning of the lighter half of the year.

Whatever year that tradition started, eventually, and to this day, the month of March has strayed from the constellation Ares, due most likely to the ‘procession of the equinoxes’ which is the topic of this paper, so that, first, the calendrical month of March slipped from alignment with the constellation Ares which it corresponded to before, to aligning with Pisces, and now has cut into Aquarius, which takes up the first sixteen or seventeen days of March in the twenty first century, and aligns with Pisces from the middle of March to the end of that month. So that the author, whose birthday is the first of March considers the Sun to be in Aquarius on his day of birth, and infers a span of time since that day was the first degree of Ares, when ancient Romans used that as the beginning of the year.

However, March still occupies the equinoctial month of the spring, and still overlaps the equinoctial point with about half the month falling before the equinox (March 21st, 22nd) and the rest falling afterwards, just as that same calendrical month did in ancient Rome. Thus, the author has reason to believe that the calendrical months are somehow fixed to the seasons as we have them, and that the zodiacal months vary in relation to perhaps both.

That is partially why I came to the theory at hand, from examining what is the same and what is different from March 1st in the twenty-first century compared with the same calendrical date in the time of ancient Rome. First, that the zodiac sign the sun occupies on that day has shifted about one and a half signs, from the first degree of Ares through Pisces to the seventeenth degree of Aquarius (counting backwards from the thirtieth degree first, though I count the entrance as the first degree of occupation). And secondly, that March 1st still falls before the equinox as far as it fell before the equinox in ancient Roman times, or, since there isn't a set date to go off, since the age of Ares. Also, the first degree of Ares in the (beginning of the) twenty-first century occurs around April 13th, about 43 days later than it did in the age of Ares, when the Sun was in that constellation in that age, or after one and a half signs of equinoctial procession.

The developing theory should be restated at this point to claim that the calendrical months are fixed to the seasons, to the equinoxes and solstices, and are meant to vary in relation to the equinoctial drift (of the zodiac in relation to the seasons), and that those cardinal seasonal points are meant to drift in relation to the zodiacal signs as well; or that the seasonal position of the sun along the zodiacal constellations is meant to drift from both the seasonal points and the calendrical months, the latter two meaning to be fixed to each other.

So, given that the zodiacal months vary in relation to the seasons or the equinox, and that the calendrical months are fixed to the seasons, so as also set to vary in relation to the zodiacal months, but not in relation to the seasonal equinoxes and solstices, there are reasons why the calendrical months were set up in that way.

The value of predicting the oncoming season plays a critical role in human affairs. Agriculture, which has multiple variables that can wreck a crop, and which would be unavoidable without some clear line drawn between the different seasons, benefits greatly from set calendrical months for that purpose, so that farmers aren't dependent on witnessing the heliacal rising of some star, which would be their only means of determining when to plant and harvest. Navigation requires the same support from the calendrical month. And although seafarers would be more acquainted than most with the directional constellations that lead them like a compass, even ancient captains would use the support of the calendrical months, in Athens for example, to determine when the 'sailing season' began and ended, to avoid storm and shipwreck. Thus, the calendrical months work as a sort of almanac for those and other professions that are not concerned with celestial phenomena besides for the task over which their craft or profession depends. And it would be too much to ask, although ideally those professions should be aware of celestial phenomena that affect their success and safety, for them to be able to notice the first sighting of the Pleaides or Canis Major after one of those pass from the visual field for a month or so, for example. For non-astronomers that require a precise timing about these matters, then, there is a weighty need for a calendrical system of months, since, of course, less than enough of them are aware of the signals of the changing of seasons without the calendar, and their whole activity depends on the right timing of the seasons. Thus, a sighting of the oncoming zodiacal sign isn't enough for productive activities and navigation, and the majority of agriculturalists and navigators require, and have in previous ages too (see Plato's critique of his own times), always required a calendrical system of months and days to determine when to plant and harvest, and when to set sail at the commencement of the sailing season and when to find harbor at the culmination of the season.

There is, then, a value in a double system comprising calendrical and zodiacal months, not only for the sake of fixation, as my own interest seeks to find, but, for practical purposes the calendrical month tied to the seasons is most useful and indispensable, while, perhaps, for astronomical purposes the zodiac plays a pivotal role, and is equally important, since a calendrical set of months without constellations lacks a visual, tangible, and even substantial basis.

As the zodiacal months vary in relation to the seasons (i.e. equinox), but have a substantial basis in the constellations, which the calendrical months do not, but the calendrical months are more approachable *without* orientation to the fixed stars, and play a role in practical and public affairs, and also, in accordance with this theory, are fixed in terms of the seasons, so that the calendrical month of both equinoxes and solstices remains the same, both support each other and are required for human affairs. Else, without the zodiacal months the calendrical months would have no basis, and would no longer be grounded in the constellations, but would be reduced to charts without substance; and without the calendrical months many trades would be incommunicable to people not versed in astronomy, including public affairs and common holidays. Thus, there is, for this thesis, a significant reason for the calendrical months, which are more at stake in requiring an explanation, and also, a significant reason for their requiring a knowledge of the place of the sun along the zodiac, which is a more astronomical subject of knowledge, without regards to practical affairs.

In other words, the calendrical month might be thought to be a 'seasonal' month, since it is not allowed to wander from the cardinal seasonal points, but the zodiacal month is.

It should be recalled that March 21st, 22nd, or 23rd, and September 21st, 22nd, or 23rd, have for ages held the position of the equinox, and that the zodiac sign that the sun inhabits at either equinox has slipped, as the system predicted and was set in place to either correct or simply remain, so that one or another constellation would house the Sun during those seasonal points, without any difference entering between the calendrical month and the cardinal seasonal point, whether it be spring or fall or summer or winter.

Then it ought to be considered significant to this theory that the "wheel of the year", in 'northern pagan' terms, set a holidays in terms of the calendrical month, where the first of May, the first of August, the first of November, and the first of February each held the place of a holiday as four cardinal points in the calendar, rather than (only) the four cardinal seasonal points. And it should be conceded that the 'wheel of the year' used the four total equinoxes and solstices as additional holidays, however, my interest is in their use of those four calendrical days, and I think that without those, they would fall victim to the same problems that this theory has used as an obstacle, namely, that without the calendrical months, and some holidays according to that, there would be a gradual error over a span of time. That is, if they had only used equinoxes and solstices, the zodiacal constellations would slip their grasp over the course of an age or two, and, especially, that in order to hold on to the equinox and solstice points they require some calendrical system of months that differs from, and is let to vary from, the zodiacal divisions, and that is fixed with those four seasonal points. That 'wheel of the year' is especially balanced because it also contains the equinox and solstice points, aside from the quaternal calendrical points. However, there is no reference to the occurrent zodiacal sign whatsoever, in either the four seasonal or four calendrical holidays that make up their eight holidays. And since those were shown to be fixed to each other, the calendrical months and seasons, and they chose to, with many others, set the seasonal points in the midst of the relevant calendrical months (middle of March, June, September, and December), and then they set the four purely calendrical holidays at the first day of the relevant month that falls half way between those seasonal points (May 1st, August 1st, November 1st, i.e. Halloween, and February 1st), those making a diamond at 45 degree angles to the four seasonal points which make a perpendicular cross from the base, and together all eight make an eight pointed star, they set their holidays without reference to the zodiac signs; since, the zodiac sign the Sun inhabits at the time of either of the four cardinal seasonal points or the cardinal calendrical months starting on the first of that month are all liable to change, and do, in terms of what sign the Sun occupies during that season or month. For example, both the spring or fall equinox and May 1st or August 1st will inevitable each fall within a different sign after the span of around two thousand years. Accordingly, those eight holidays designated in their "wheel of the year" are concerned particularly with the seasons and the calendrical months that are tied to the seasons, without reference to the zodiacal sign that the Sun inhabits during any of the first days of those months or the equinoxes and solstices (in the middle of other months) which all may and do vary in relation to the zodiac signs over the ages. Thus, something prompted the developers of that holiday calendar to choose to diverge from the constellational signs of the zodiac, which shift along the ages in terms of the seasons and months, and focus on the seasons and months themselves, which I have tried to show are fixed in relation to each other but vary in relation to the zodiac sign that corresponds during that age. And, although I have said that the constellations are necessary for a substantial root in astronomy, I have also praised the practical and public use of seasons, in comparison to a purely astronomical understanding based on constellations without seasons or calendrical months.

The Egyptians used a contrasting means to determine the beginning of the year. Rather than season (i.e. equinoxes and solstices), they used the heliacal rising of a fixed star tied to a certain constellation in the zodiac; so regardless of the season, though they were said to celebrate new years in the fall, they specifically determined the onset of the year by the Sun's passing Canis Major, in the sign Cancer, without regard to the season or calendrical month, even if it happened to take place in the (summer or) fall. Their focus may be thought to be primarily on the constellational position of the Sun, even if the Sun's passing Canis Major would inevitably occur during a different season over time, and would likewise fall within a different calendrical month. Since their civilization spanned an incredible period of time, they must have delt with this problem thoroughly.

There is, of course, a benefit and harm to both modes of reckoning the beginning of the year. The focus of the Egyptians was the Sun's returning to a specific star after its annual cycle, regardless of the season and regardless of the calendrical month. Perhaps they set the months in accordance with that phenomenon, and made nominal corrections to the other two variables, the calendar and the seasons. I suppose the advantage of the Egyptian system of reckoning the beginning of the year by a fixed star like Canis Major is the accuracy of determining the Sun's return to the same point along its annual cycle astronomically, since the seasonal difference between the week before the equinox and the week after isn't obvious to the observer and requires further mechanisms in order to measure the length of days and nights; not to mention the addition of twilight, or of dawn and dusk which refuse to let the day and night be divided into two halves for the convenience of that measurement.

Thus, the two methods are at odds about the number of days in a year, rather than any problem about the equinoctial shift or ‘ages’; and the Egyptian method argues for a three hundred and sixty day year, one degree of the circle per one day, while the seasonal-calendrical method argues for a year of three hundred and sixty four or five days, and has continually tried to correct that measurement by the addition of decimals. There is something harmonious about a year that corresponds to a circle, one day to each degree, and something ungraceful about the number of days in the year leaving a decimal left over, so that half of the last day of the year falls on the same day as the first day of the following year.

Given that the year is divided into ‘days’, and days are whole units, not hours or minutes, any attempt at determining the number of days in a year should not rest content with an incomplete last day of the year lending its second half to the following year. Even for calendrical purposes that throws a wrench in the wheel of the following year, and of course would, with time, increase the error; as a minor error at first, with proportional accumulation over time, increases to a more significant and obvious inaccuracy.

Now, the purpose of this argument is to examine the calendar and other annual systems of measurement (like the zodiac) in terms of stability or instability over equinoctial ages, not to determine the number of days in a year. However, that is a significant factor in the purpose at hand, since an error in the number of days in the year would eventually add up over an equinoctial age to an unwanted problem for future astronomers, and perhaps, though not definitely, has. With what will be shown later, I will claim that the reckoning of days and months in a year should be treated as an abstraction without concern to other years, and that the correction of what day the beginning of the year is placed is the matter to be corrected over ages of time, i.e. millennium.

There is an advantage to be mentioned about using the ‘heliacal rising’ of a fixed star, as the Egyptians did Canis Major. With such a visually determinate measure, there is a greater accuracy in observing when the Sun returns to the same single point in its annual cycle, astronomically, since the difference between the week before the equinox and the week after isn’t obvious and requires other mechanisms to determine, like the observation of shadows around the summer solstice at the tropic of Cancer, which used to be conducted at a hundred gated Thebes (which requires the addition of the knowledge of latitudes; and since a bright star that stands out in the sky lends a sort of obvious boundary which we can wait for the Sun to pass (or wait to disappear and reappear in the sky), instead of (by another means) trying to use the first degree of a zodiac sign, which may not have a recognizable star at its first degree or may even have a couple degree gap between it and the last star of the sign before it. So, not only are those alternative means insufficient to determine, especially, the days of a year to the decimal point, using one of the brightest and easiest stars to observe, for a sheet of vaporous cloud could restrict the vision of most other stars, makes for a simpler observation and calculation.

Now, regardless of the number of days in a year, the same means can be used for keeping up with the equinoctial shift over ages, although the equinoctial ages are marked by the Sun's entering a zodiac sign, and there are limited commonly known bright stars to mark the position of the Sun, and also, they don't fall at the first degree of any sign we wish to determine the time of the Sun's occupation there at the equinox. The Egyptians must have been less concerned, at least by that means, with determining the onset of a new equinoctial sign by setting the beginning of the year at Canis Major, somewhere vaguely in the midst of Cancer, without regard to the orientation of that or any other sign's housing the Sun at the seasonal equinox.

Just as the Sun eventually occupies a different sign at the seasonal equinox, and the Sun's position in any one sign varies over the course of ages in terms of the season that occurs, the Sun passes Canis Major at a different time of the year, or in a different season, over the ages. Then as said above, their exclusion of seasonal and calendrical variables for determining the Sun's returning to the same point in its cycle provides a more stable base for marking the beginning of the year, as they considered only the spatial position of that luminary.

Moving on from the problem of the number of days in a year and how to determine that, we can adopt the same means, i.e. the Dog Star, as a measure for tracking the equinoctial ages and the change of zodiac signs that the Sun inhabits during the equinox. For, I will attempt to show the use of that alongside the other variables, i.e. what sign the Sun occupies in the spring and what month that occurs in. In the same way a third variable was supposed to the useful for 'triangulating' one of the other two, we can consider Canis Major as playing the role the fixed zodiac signs played in earlier speculation in relation to both the seasons and the calendrical months, since that is a fixed star as well and is set in Cancer, though not at the very beginning of that sign so as to tell us anything about the onset of that sign. And the calendrical months will be shown to play an important role in the equation, without which there would be a redundancy in saying that "when the Sun reached the equinoctial point in some sign (during the spring), the Sun later reached Canis Major or Cancer in such and such a season, say, summer or fall", without a calendrical month to set the latter half of the equation.

It would be helpful to restate the points made thus far. First, it was shown the necessity for keeping records of calendrical and zodiacal months which slowly change in relation to each other. Also, that the calendrical months (i.e. January, February, etc.) are set in accordance with the seasons so as not to vary over millennia, whereas the zodiacal months suffer the effect of equinoctial drift. Then, two different means used by different civilizations (in perhaps different eras), northern pagan and Egyptian, were shown to mark the beginning of the year, and the objective of either of their attempts—to determine the length or number of days in a year. After that it was claimed that regardless of the number of days in a year and the beginning point of the annual cycle, there are inevitable corrections (not only for errors made but for a separate cycle altogether) to make up for the variation of either variable that they choose as a measure, whether calendrical-seasonal or zodiacal, i.e. fixed stars. Both systems require hindsight over a couple millennia to adjust to the equinoctial drift. It was also stated that this problem of hindsight correction for the procession of the equinoxes is a different problem than the number of days in a year and the beginning point of the year; since, the Sun won’t be in Canis Major during the same season in future ages, even if they erred not in determining the number of days in a year, nor by using Canis Major as herald of the new year; and neither will the season be stable with regard to the Sun’s position in the zodiac over time, even if the other camp rightfully records the onset of the year by its seasons, i.e. equinoxes and solstices.

Now, we may continue with the long-term problem of examining the effect of the equinoctial procession on either of those systems of annual measurement. I suggest using the Egyptian means of determining the beginning of the year (Canis Major) for this other end. As one of the brightest fixed stars offers a less sophisticated and more obvious mechanism for determining the return of the Sun to the same point in its annual cycle compared to trying to measure the length of hours of daylight and night to find the balance between them, that will grant us a more stable mark of the beginning of the year to see how much has changed over the ages in relation to the other two variables, calendrical months and seasons, which have been shown to be invariable to each other.

Again, since our focus isn't on the placement of the beginning of the year per se, but how far that's changed over time, yet we require a stable yearly cycle to even calculate the equinoctial procession, I suggest using that as a fixed variable against the changing variable of an equinoctial sign in some given age; as the latter equation and results will show. Once more, this latter problem only questions the past and the length of time between ages, rather than trying to proclaim the accuracy of some method of determining the length or beginning of the year. And in favoring the Egyptian method for that, I ultimately mean to show the value of the calendrical months as nonvariant from the seasons, though neither provide us with a recipe for dealing with equinoctial procession on their own right. Thus, given some beginning of the year (which for making the equation is up for choice), we can calculate the equinoctial shift since past ages. The greater problem as I see it is to figure out how far along we are through the ages, from the seasonal difference since then of when the Sun occupies the same position along the zodiac during its annual cycle.

The formula will run as follows:
During the age of [variable 1], the Sun was in Cancer, i.e. at Canis Major on [variable 2, calendrical month]
In other words,
When the spring equinox reached [some zodiac sign], the Sun passed the Dog Star, i.e. the sign of Cancer on [some calendrical month, variable 2]

The objective is to find a fixed rate of change between the change of the sign the Sun is in at the spring equinox and what calendrical month the Sun passes through Cancer and the Dog Star.

For the sake of not straying too far in the past, where historical records are nil, the equinoctial signs [variable 1] will be selected from the few recent ages which have been assigned historical or at least mythological content, however the records only show at most three ages before the spring equinox was in Pisces, which is where it is now. So, the formula will be spelled out for those ages, and a chart will be provided to fill in the previous ages before those and the ages after the next. Few historical and mythological records will be provided for contextualization. The first age mentioned, when the Sun was in Gemini at the spring equinox is entirely mythological, without any figures, not even a king of a state, with scarce literary mention, and entirely up for debate. I think it important to start with the age just before historical and mythological records pour in.

When the Sun reached the spring equinox in Gemini, the Sun passed into Cancer (or the heliacal rising of the Dog Star) around May 1st.
When the Sun reached the spring equinox in Taurus (4000 bc), the Sun passed into Cancer around June 1st.
When the Sun reached the spring equinox in Ares (1800/1600 bc), the Sun passed into Cancer around July 1st.
When the Sun reached the spring equinox in Pisces (325 ad), its current place in that season, the Sun passed into Cancer around August 1st.

And when the Sun reaches the spring equinox in Aquarius (around 2400 ad), the Sun will pass into Cancer around September 1st.

The age of Gemini is scarcely noted.
The age of Taurus is filled with the onset of civilizations like Egypt and Minoan Crete. The first king of Egypt, Menes, was said to live around 3000 bc, and the Minoans thrived with their palaces on Crete and controlled maritime trade in the Aegean and through most of the Mediterranean during that age too. Important to note is that the end of the age of Taurus, when the age of Ares began around 1800 or 1600 bc, resulted in the complete destruction of both civilizations due to the Thera Volcano, which decimated the Middle Kingdom and historically marks the time of the exodus of many peoples from Egypt, which served as a refuge for nearby peoples due to its lack of clouds, rain, and predictable weather, along with an abundance of grain and therefore wealth through export.

The age of Ares resulted from the mass exodus from Egypt and Crete. Dardanus founded Troy directly after that catastrophe, around 1800 bc, historically and mythologically recorded as surviving 'the flood' and escaping to Asia Minor, and after descending from the mountains founded that holy city on the plains beneath Mt. Ida. Danaus, Cecrops, and Cadmus, among others, fled to Greece at the same time and introducing institutions like digging wells, marriage, and law in Argos, Athens, and Thebes (seven gated Thebes likely named after a hundred gated Thebes in Egypt) respectively. The Phoenicians have a similar story and at the same time set up Sidon, Tyre, and Biblos at the start of the age of Ares, and they also founded Carthage in that era. The fall of Troy occurred during that same age, around 500 years later. Rome was founded during that same age and its fall and relocation to Byzantium along with the foundation of the Holy Roman Empire come close to marking the end of the age of Ares.

The most common claim for the beginning of the Piscean age is the council of Nicaea at 325 ad, however anywhere within a century on either side of that functions for this purpose. ‘The crisis of the third century’ might give a broad range of time which instability resulting from radical changes in every walk of life brought the age of Pisces into being.

The age of Aquarius is a future matter of speculation, in my opinion five or six degrees away (multiplied by sixty or seventy-two years per degree), setting us at least 300 years away. That brief historical sketch is only meant to contextualize the time periods listed, and shouldn’t distract from the purpose of the formula provided.

Again, the objective is to find a fixed rate of change between the changing signs the Sun occupies at the spring equinox and what calendrical month the Sun passes through Cancer and the Dog Star.

From the shifting of the spring equinox in Gemini to the spring equinox in Taurus (according to the table above), the calendrical month the Sun was in Cancer shifted from May 1st to June 1st.

And the shifting of the spring equinox from Taurus to Ares, coincided with the shift of the Sun's position in Cancer from June 1st to July 1st.

Then, as the spring equinox shifted from Ares to Pisces, the Sun's position in Cancer shifted from July 1st to August 1st.

And when the spring equinox shifts from Pisces to Aquarius, the Sun's position in Cancer will be shifted from August 1st to September 1st.

So that, every time the spring equinox shifts from one zodiac sign to the next, the time of year that the Sun occupies Cancer progresses to the next calendrical month, in a 1:1 ratio.

So, as I like to start from the age of Cancer, when the spring equinox was there, because that makes an obvious start; in that age the Sun was clearly in Cancer in the spring, and a specific beginning of a month can be placed at April 1st, just after the equinox (especially since Canis major isn't in the first part of that sign). With the onset of Gemini, where the previous chart began due to historical and mythological scarcity, we find the Sun in Cancer around May 1st… And so on, with the oncoming equinoctial sign, Cancer's position in the annual cycle falls to June 1st in the age of Taurus, etc. Until in the age following the next, when the spring equinox is in Capricorn, the Sun will be in Cancer passing Canis Major during the fall equinox, opposite of the Sun's position in the spring. For the sake of consistency this chart places the Sun there on October 1st, to keep to the first of the months. Then a 1 equinoctial age: 1 month of change of the Sun in Cancer can be inferred as a regular interval, proportionally the same and predictable.

And although the objective of this inquiry was to find a set point of the beginning of the year that doesn't suffer from equinoctial shift, a fixed ratio of variation, with both variables proceeding together, eventually brings the measure of Canis Major back to the same point of the greater cycle, where it will be occupied by the Sun in the same month that it did during the same equinoctial age before. And the Sun won't stray from aligning with Cancer during the month it did during such and such an equinoctial age, although it cycles through the months in step with the shift of equinox.

BIBLIOGRAPHY

Aristotle. De Caelo.

Aristotle. Physica.

Cicero. De Re Publica. VI. Somnium Scipionis

Euripides. Oresteia

Galileo. Dialogue Concerning the Two Chief World Systems.

Galileo. Discourses and Mathematical Demonstrations Relating to the Two New Sciences

Heidegger. The Principle of Reason.

Hesiod. Theogony

Plato. Laws.

Plato. Phaedo.

Plato. The Republic.